POWER PLANT ENGINEERING

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Du Pont Plant Shows Fine Safety Record

POWER DEPARTMENT OF MORE THAN 50 MEN AT DEEP WATER POINT, N. J., GOES THREE YEARS WITHOUT A LOST TIME ACCIDENT

ASSUMING you were head of a power department employing 50 men and if during the course of more than 3 yr. not a man was forced to take time off for accidents, you would have reason to feel proud of your record, would you not? It is quite natural, then, that A. L. Brown, power superintendent of the Dye Works of E. I. du Pont de Nemours & Co. at Deep Water Point, New Jersey, should feel the elation which goes with a job well done. His plant has just such a record.

In 1919 there had been 10 major accidents, resulting in lost time of 77 man days and $1685 monetary loss to the company. In 1918 nine major accidents caused a loss of 182 man days and $2518 in temporary and permanent compensation.

From these few figures it can be seen just what 3 yr. without lost time accidents has meant to the company in the saving in man hours and in reduction of compensation expense. These reductions are important as pointed out by J. H. Barnholt, who is head of the safety department for the dye works, but not nearly as important as the reduction in suffering.

Since this is the only department in this vast industrial works that has a perfect record for such a period of time, what is the secret of Mr. Brown's success? Is it because the work of the power department is an inherently safer occupation than that of other departments? In answer to this question Mr. Barnholt affirmed emphatically that frequently the power department in other du Pont plants is the worst offender in the number of lost time accidents. It was due entirely, he said, to the spirit of the department and the attitude which they took toward safety work.

When Mr. Brown was approached on the same subject he explained it along the following lines: "We believe that the answer lies in the fact that every man from the *top down*, not from the bottom up, has been sold 100 per cent on safety. That in itself is not such an easy matter. I remember when the du Pont organization first put on a man to work on safety at the general office at Wilmington and began a campaign at the various plants. We thought it about the most foolish thing we had heard of. Our idea in the old days was that if a man met with an accident it was his own fault and was to be expected as a part of the normal working hazard. I think it was several years before I was thoroughly sold on the value of safety work. Certainly if the heads and assistant heads of departments are not in sympathy with such work, it can hardly be expected that the men will take much of an interest in safety. The head of the department and the fore-

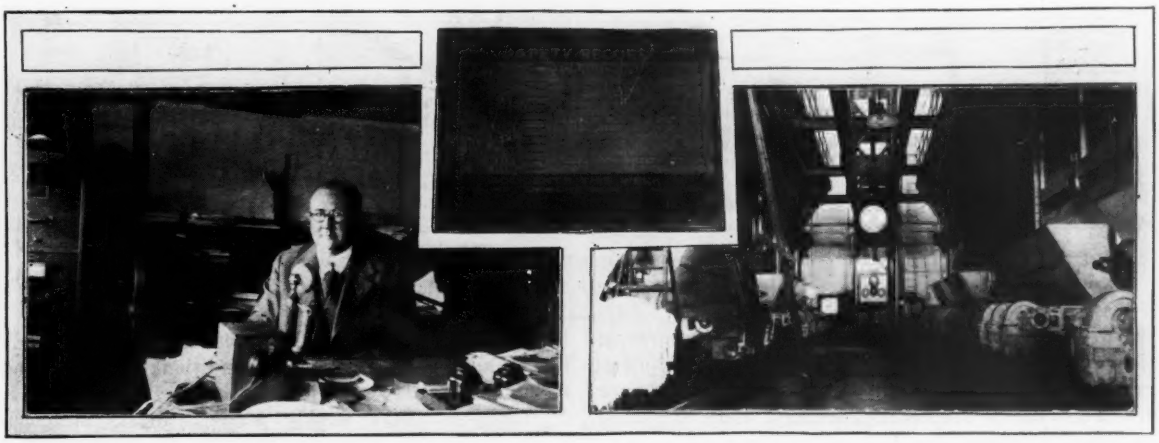


FIG. 1. A. L. BROWN, POWER SUPERINTENDENT, LOOKS ON SAFETY WORK AS ONE OF THE IMPORTANT DUTIES OF A POWER PLANT EXECUTIVE

men must take the viewpoint that all accidents are their fault, rather than place the blame on the man who meets with the accident."

From this summary of viewpoints on safety work, it is evident that the record is not one of good luck, but is due entirely to the methods which have been followed.

As previously mentioned, during the year 1918 there were nine major accidents, and at the beginning of 1919 steps were taken to organize the safety work on a definite basis, although during that year the results did not begin to show up until 1920.

Safety Meetings Are Held

As a part of the plan, weekly meetings were instituted at which men in various capacities, from power superintendent to coal passers, attend. It is not always possible, of course, for all of the men to attend, due to the nature of their operations, but as the shifts vary from week to week, it is possible during the course of the month to have all of the force to attend these meetings. All of the men have an equal right on the floor and minutes of the proceedings are kept and distributed to interested persons.

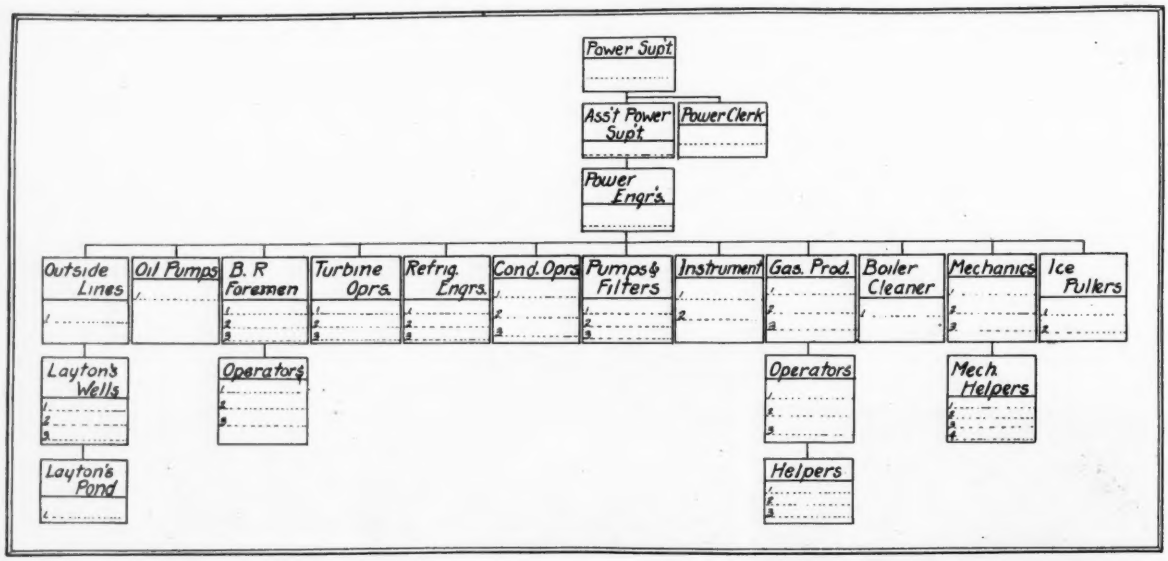


FIG 2. ORGANIZATION PLAN OF THE POWER DEPARTMENT SHOWING THE RELATION OF THE VARIOUS SUB-DIVISIONS OF THE WORK

At these meetings unsafe practices which are observed during the week, violations of safety rules and suggestions for increased safety are brought to the attention of the men. For instance, suggestions are received regarding the installation of safety appliance, such as guards around flyball governors, flywheels, pump plungers, leads to high potential motors, switchboards, safety treads installed on ladders, toe boards on overhead walk-ways, platforms, etc.

During 1919, complete power department logs were started, automatic mechanical safety appliances, such as high-speed turbine stops, air compressor governors and other apparatus, was tested in actual operation semi-monthly and the performance reported. Fusible plugs were installed on all boilers and these were removed every nine months, although the state law did not require it. Boilers were cleaned and inspected at frequent intervals.

Periodically letters from the power superintendent are addressed to each of the men in the department, calling attention to the record by stating the number of days which have passed without an accident and asking for suggestions by which to maintain the record. In Fig. 3 may be noted one of these letters which was sent out on Jan. 19, 1923, asking for suggestions as to what steps might be taken to assure the record being maintained.

Every two weeks a complete record is turned in which is called the "Safety and Housekeeping Report" and which covers the entire power department. This report is made by one of the operating men, a different man being delegated for the job for each report. The report covers conditions in the turbine room, boiler room, pump house, compressor room and other parts of the plant, as will be noted from the form shown in Fig. 3. In this report, the observer makes recommendations and calls attention to conditions which do not seem to be satisfactory from a safety standpoint.

There is also a weekly personal injury statement which covers the entire dye works by departments. This not only covers the number of accidents which have occurred during the week, but also describes just how the accident occurred. In addition to this report, there are two bulletin boards at the main entrances of the plant, on which the record of that date is posted. In this way it is possible to secure the interest of all the men and to place the departments on a competitive basis. Accidents which have occurred during the week are also described in detail on this board so that everybody in the plant is kept informed as to exactly how accidents happen.

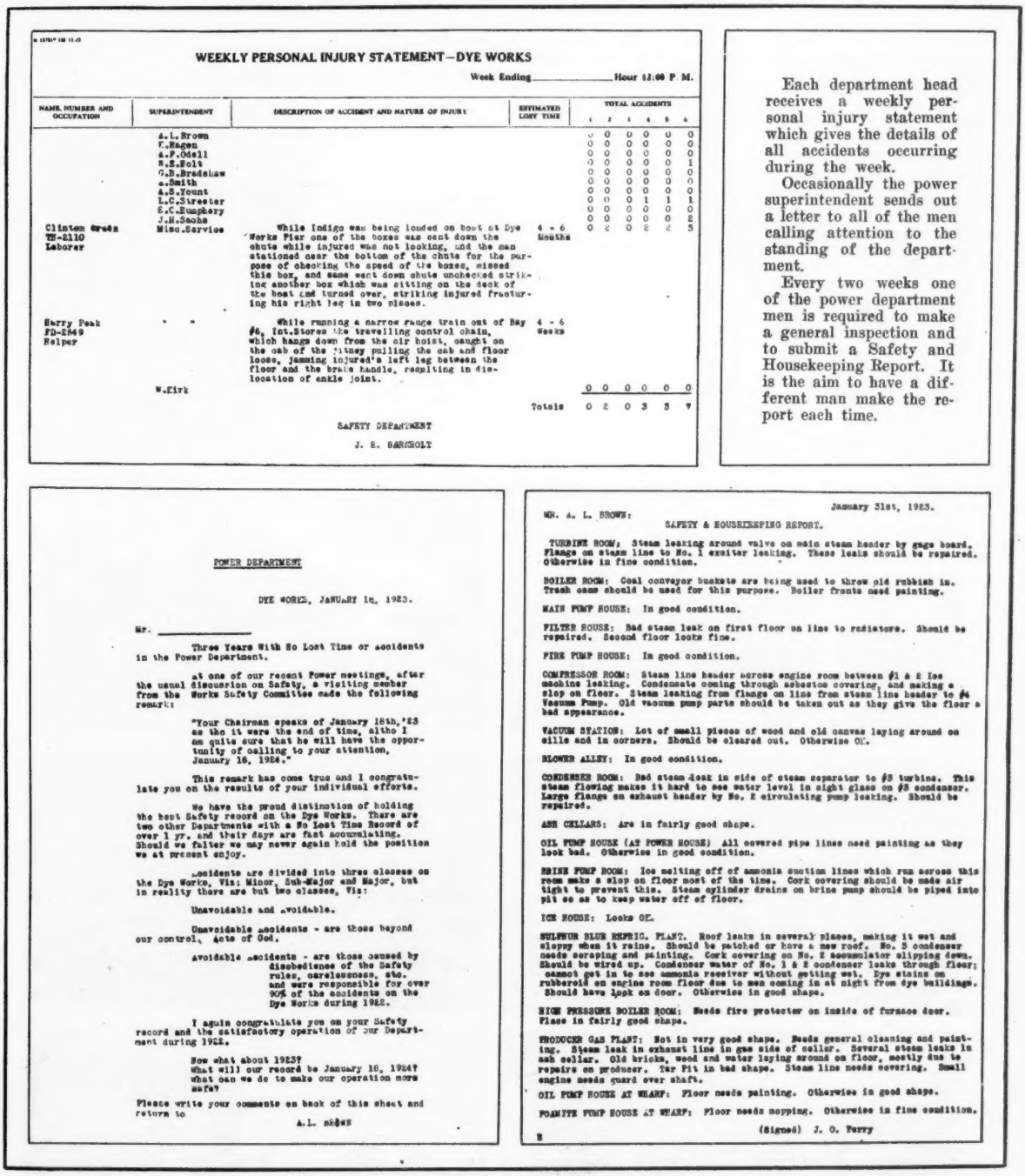
Accidents are classified into major, sub-major and minor types. Accidents of a major character are those which cause loss of time, while sub-major accidents are those of the character which do not totally incapacitate a man and which allow him to follow other work

for a time if he is not able to carry on his regular duties. Minor accidents are those which can be taken care of in the company hospital and which do not involve any loss of time or change of work.

At the weekly meetings which are held in the power department the major and sub-major accidents are discussed with a view to presenting methods which will eliminate such hazards as have caused the accident. During the last 3 yr., however, there have not been any major accidents to discuss, as has been previously stated.

From the standpoint of the power department the importance of reduction in lost time accidents not only includes the monetary value of compensation which is saved and the reduction in suffering, but makes for a better working efficiency. If men are off duty, due to lost time, it usually means that a part of this work falls on the regular force, since power plant work is so specialized that it is not always possible to have men available who can step in and take over a particular job without causing a breaking up of the regular routine. In the opinion of Mr. Barnholt, this is, in itself, a point of no mean importance.

It is not alone from a safety standpoint that this



WEEKLY PERSONAL INJURY STATEMENT—DYE WORKS

Week Ending _____ Hour 12:00 P. M.

NAME, NUMBER AND OCCUPATION	SUPERINTENDENT	DESCRIPTION OF ACCIDENT AND NATURE OF INJURY	ESTIMATED LOST TIME	TOTAL ACCIDENTS 1	2	3	4	5	6
	A.L.Brown			0	0	0	0	0	0
	F.Hagen			0	0	0	0	0	0
	A.F.Odell			0	0	0	0	0	0
	H.E.Holt			0	0	0	0	0	1
	G.B.Bradshaw			0	0	0	0	0	0
	A.Smith			0	0	0	0	0	0
	A.S.Mount			0	0	0	0	0	0
	L.C.Streeter			0	0	0	1	1	1
	E.C.Humphery			0	0	0	0	0	0
	J.H.Sachs			0	0	0	0	0	1
Clinton Wade TH-2110 Laborer	Misc.Service	While indigo was being loaded on boat at Dye Works Pier one of the boxes was sent down the chute while injured was not looking, and the man stationed near the bottom of the chute for the purpose of checking the speed of the boxes, missed this box, and same went down chute unchecked striking another box which was sitting on the deck of the boat and turned over, striking injured fracturing his right leg in two places.	4 - 6 Months	0	1	0	2	1	3
Harry Peak FD-2549 Helper	" "	While running a narrow gauge train out of Bay #6, Int.Stores the travelling control chain, which hangs down from the air hoist, caught on the cab of the tinney pulling the cab and floor loose, jamming injured's left leg between the floor and the brake handle, resulting in dislocation of ankle joint.	4 - 6 Weeks						
	W.Kirk			0	0	0	0	0	0
			Totals	0	1	0	3	3	7

SAFETY DEPARTMENT

J. E. BARNHOLT

Each department head receives a weekly personal injury statement which gives the details of all accidents occurring during the week.

Occasionally the power superintendent sends out a letter to all of the men calling attention to the standing of the department.

Every two weeks one of the power department men is required to make a general inspection and to submit a Safety and Housekeeping Report. It is the aim to have a different man make the report each time.

POWER DEPARTMENT

DYE WORKS, JANUARY 1st, 1923.

Mr. _____

Three Years With No Lost Time or Accidents in the Power Department.

At one of our recent Power meetings, after the usual discussion on Safety, a visiting member from the Works Safety Committee made the following remark:

"Your Chairman speaks of January 16th,'23 as tho it were the end of time, altho I am quite sure that he will have the opportunity of calling to your attention, January 16, 1924."

This remark has come true and I congratulate you on the results of your individual efforts.

We have the proud distinction of holding the best Safety record on the Dye Works. There are two other Departments with a No Lost Time Record of over 1 yr. and their days are fast accumulating. Should we falter we may never again hold the position we at present enjoy.

Accidents are divided into three classes on the Dye Works, Viz: Minor, Sub-Major and Major, but in reality there are but two classes, Viz:

Unavoidable and Avoidable.

Unavoidable Accidents - are those beyond our control, Acts of God.

Avoidable Accidents - are those caused by disobedience of the Safety rules, carelessness, etc. and were responsible for over 90% of the accidents on the Dye Works during 1922.

I again congratulate you on your Safety record and the satisfactory operation of our Department during 1922.

Now what about 1923? What will our record be January 16, 1924? What can we do to make our operation more safe?

Please write your comments on back of this sheet and return to

A.L. BROWN

January 31st, 1923.

MR. A. L. BROWN:

SAFETY & HOUSEKEEPING REPORT.

TURBINE ROOM: Steam leaking around valve on main steam header by gage board. Flange on steam line to No. 1 exciter leaking. These leaks should be repaired. Otherwise in fine condition.

BOILER ROOM: Coal conveyor buckets are being used to throw old rubbish in. Trash cans should be used for this purpose. Boiler fronts need painting.

MAIN PUMP HOUSE: In good condition.

FILTER HOUSE: Bad steam leak on first floor on line to radiators. Should be repaired. Second floor looks fine.

FIRE PUMP HOUSE: In good condition.

COMPRESSOR ROOM: Steam line header across engine room between #1 & 2 Ice machine leaking. Condensate coming through asbestos covering, and making a slop on floor. Steam leaking from flange on line from steam line header to #4 Vacuum Pump. Old vacuum pump parts should be taken out as they give the floor a bad appearance.

VACUUM STATION: Lot of small pieces of wood and old canvas laying around on sills and in corners. Should be cleared out. Otherwise O.K.

BLOWER ALLEY: In good condition.

CONDENSER ROOM: Bad steam leak in side of steam separator to #3 turbine. This steam flowing makes it hard to see water level in sight glass on #3 condenser. Large flange on exhaust header by No. 2 circulating pump leaking. Should be repaired.

ASH CELLARS: Are in fairly good shape.

OIL PUMP HOUSE (AT POWER HOUSE) All covered pipe lines need painting as they look bad. Otherwise in good condition.

BRINE PUMP ROOM: Ice melting off of ammonia suction lines which run across this room make a slop on floor most of the time. Cork covering should be made air tight to prevent this. Steam cylinder drains on brine pump should be piped into pit so as to keep water off of floor.

ICE HOUSE: Looks O.K.

SULPHUR BLUE REFRIG. PLANT. Roof leaks in several places, making it wet and sloppy when it rains. Should be patched or have a new roof. No. 3 condenser needs scraping and painting. Cork covering on No. 2 accumulator slipping down. Should be wired up. Condenser water of No. 1 & 2 condenser leaks through floor; cannot get in to see ammonia receiver without getting wet. Dye stains on rubberoid on engine room floor due to men coming in at night from dye buildings. Should have lock on door. Otherwise in good shape.

HIGH PRESSURE BOILER ROOM: Needs fire protector on inside of furnace door. Place in fairly good shape.

PRODUCER GAS PLANT: Not in very good shape. Needs general cleaning and painting. Steam leak in exhaust line in gas side of cellar. Several steam leaks in ash cellar. Old bricks, wood and water laying around on floor, mostly due to repairs on producer. Tar Pit in bad shape. Steam line needs covering. Small engine needs guard over shaft.

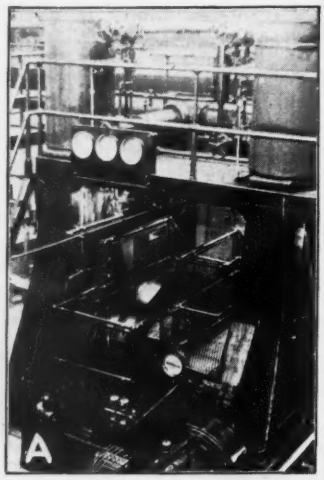
OIL PUMP HOUSE AT WHARF: Floor needs painting. Otherwise in good shape.

FOAMITE PUMP HOUSE AT WHARF: Floor needs mopping. Otherwise in fine condition.

(Signed) J. O. Perry

FIG. 3. RECORD SYSTEM STIMULATES SAFETY

Fig. 4. In Handling the Diversified Equipment of a Large Industrial Power System, Safety Work Is Especially Important



A. One of the two 100-T. ice machines which are used for process work and the manufacture of ice.

B. Distribution lines pass out through this tower.

C. Turbines are pulled down and overhauled once a year.

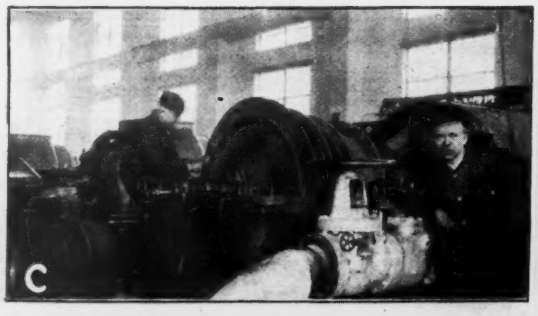
D. Each turbine has an 8 by 22 by 12-in. dry vacuum pump.

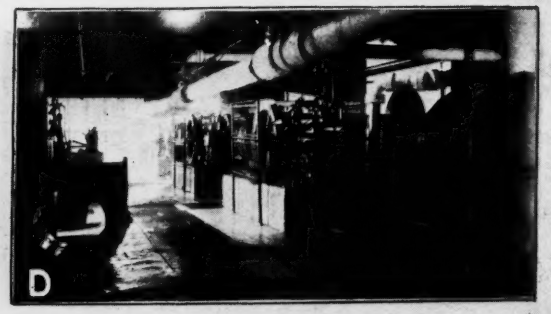
E. In the pumping station there are nine motor driven centrifugal pumps.

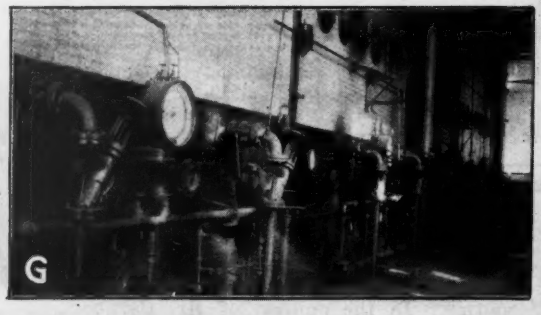
F. Another view of the pumping station which shows the central control board for starting the motors.

G. These Stirling boilers were originally stoker fired but in changing over to oil, the burners were put in at the rear and a flash wall built at the front of the setting.

H. Oil is brought in by boat and pumped to two 55,000-bbl. storage tanks.







plant has shown a good record, but also from an operating viewpoint as well. As will be noted from the organization chart, Fig. 2, the power plant itself is operated with a total of five men per shift. That is, two in the boiler room and three in the turbine room. Since this plant consists of four 1500-kw. tubo-generators, six compressors and two 100-T. ice machines and eight boilers, it can be seen that the number of operators has been reduced to what appears to be the absolute minimum.

It would not be possible, of course, for this number of operators to handle any extensive repair work and such work is handled by a repair gang which handles the work of the entire power department. The operators, however, keep the plant clean, such work being handled by the men on the night shift.

Form 1155B-500-4-20 SHEET No. 1

BOILER HOUSE OPERATION COSTS

PLANT FROM..... TO.....

	Man Hrs.	Av. Rate Per Hr	Total Cost	Cost Per Bbl. Oil Fired	Cost Per 1000 lbs. Water Evaporated	Cost Per Boiler h. p. hr.
(1) Fuel Petroleum F O B Plant						
(2) Unloading Oil and delivering to storage tanks, including pumping into working tanks						
(3) Steam for pumping to storage and working tanks, and heating systems						
(4) Delivering oil from working tanks to burners						
Total delivering oil from tanks to burners						
(5) Firing boilers ,including cleaning of burners						
(6) Boiler Cleaning						
(7) Boiler room supplies (oil, waste, compound)						
(8) Repairs, Labor— (a) Buildings						
(b) Oil Lines—supply pumps and heating systems						
(c) Boilers, breechings and stacks						
(d) Oil burners and oil feed pumps						
(e) Boiler roon piping						
(f) Tools						
Total Repairs—Labor						
(9) Repairs—Material— (a) Buildings						
(b) Oil Lines—Supply pumps and heating systems						
(c) Boilers, breechings, stacks						
(d) Oil burners oil feed pumps						
(e) Boiler room piping						
(f) Tools						
Total Repairs—Materials						
Total Repairs—Labor and Material						
(10) Direct boiler room superintendence						
(11) Proportion of cost of Power Supt and staff						
Total Superintendence						

Form 1155B-500-4-20 SHEET No. 2

BOILER HOUSE OPERATION COSTS---Continued

PLANT FROM..... TO.....

	Man Hrs	Av. Rate Per Hr	Total Cost	Cost Per Bbl. Oil Fired	Cost Per 1000 lbs. Water Evaporated	Cost Per Boiler h. p. hr.
1(2) Steam for oil feed pumps						
(13) Steam for burners						
(14) Steam for forced draft						
(15) Compressed air for cleaning tubes						
(16) B. R. Steam for blowing tubes						
(17) Electricity for lighting at..... per kw hr						
Total Boiler Room Auxiliaries						
(18) Water at.. per M gal. delivered to reservoir						
(19) Electricity for pumping feed water to heater at..... per kw hour						
(20) Steam for B. F. Pumps						
(21) Steam for boiler cleaning air compressors						
(22) Labor in operation boiler feed pumps and boiler cleaning air compressors						
(23) Supplies B F Pumps and B C air compressors						
(24) Repairs, Labor B F Pumps and B. C air compressors						
(25) Repairs, Material B F. Pumps and B C. air compressors						
Total water for boiler feed and boiler cleaning delivered to boilers						
Grand Total Costs of Boiler Room						

Total Fuel Oil Fired (Bbls.).....
Total Water fed to Boilers.....
Total Water Blown Down (including leakage).....
Total Lbs. Water Evaporated.....
Total B. H. P. Hours Delivered.....
Average F. W. Temperature.....
Average Steam Pressure.....
Equivalent evaporation from and at 212°—lbs. Water per lb. Dry Fuel Oil.....
Actual % Rating Developed.....
Average B. T. U. per lb. Dry Fuel Oil (calculated).....
Average % Moisture in Fuel Oil.....
Average B. T. U. per lb. Fuel Oil Fired.....
Average Boiler Efficiency.....

FIG. 5. BOILER ROOM COSTS ARE ENTERED ON THESE FORMS

Boilers Changed to Oil Firing

In the boiler room there are eight Stirling boilers of 823 hp., each with 680 3¼-in. tubes, of which 480 are main tubes. The steam drum is 42 in. in diameter and the mud drum 48 in. in diameter. The heating surface is 8226 sq. ft., while the grate area is 142.4 sq. ft.

Stoker equipment, which was originally installed, is made up of Riley nine retort stokers with hand control. In 1920, however, it was decided to change over to oil firing and this was done by building a flash wall at the front of the boiler and installing the burners at the rear. The stokers were covered over with a layer of scrap pipe covering, ashes and then a layer of fire brick. It is, therefore, possible to go back to coal burning on a few hours' notice. There are four burners per boiler, and Hammell, Enco and Quinn burners are in use. The oil pressure which is used varies from 70 to 75 lb. with about 20 lb. at the tip.

Although there are 8 boilers in the boiler room, only four are equipped with B. & W. superheaters, as the other four supply saturated steam for process purposes and for the compressors and ice machines. Unit operation of the superheated and saturated steam boilers is made possible by tying the two headers together and taking the turbine supply at the most remote point from the saturated steam header. Regulation is obtained by a special arrangement of a Mason governor, which operated on one boiler, and the other seven boilers are set for steady operation. The regulator controls the dampers, the oil to the burner and steam for atomization on the one boiler under regulation, which takes care of any variation in load. The boiler plant is, therefore, in reality automatic and operates at from 150 to 200 per cent of rating.

In setting the seven boilers for a predetermined rating, the basis for the amount of oil, air and atomizing steam is determined from the CO_2. This is maintained at 12 or 14 per cent. From Fig. 6 it will be noted how the CO_2 varies on the boilers which are operating without regulation, on a steady load, as shown by the left-hand chart, while on the right hand is shown variations in CO_2 in the boiler which is under regulation. Republic recording CO_2 meters are used and are so arranged that one instrument can be used on two boilers. Bailey recording meters show the draft, steam pressure, flue gas temperature and the amount of air. General Electric flow meters are also used. A large Ashton master steam gage shows the operators how the steam

pressure varies while the permanent record is taken on Bristol recording steam pressure gages. In measuring draft a portable draft gage is used, as this feature of the Bailey meter is not in service since the boilers were changed over for oil firing. Occasionally the Republic CO_2 meters are checked with a hand Orsat instrument.

Safety valves were furnished by the Consolidated Safety Valve Co. There are three valves on superheated boilers and two on those which furnish saturated steam. Foster non-return stop valves, Diamond soot blowers, Adamant gages and Yarnall-Waring blowoff valves make up other details of the installation.

There are two 2½-in. blowoff lines on each boiler which blow into a common blow down tank of about 5 by 6 ft., which is vented to the atmosphere with an 8-in. pipe. Boilers are blown down once in each 24 hr.

4½ mi. away from the station. At this pumping station there are two Lea centrifugal pumps which pump into a 24-in. wood stave pipe line. There is a gravity flow from the pond to the sedimentation concrete reservoir of 100,000 gal. which is located at the plant. From the reservoir the water passes through four Roberts gravity filters of 450 gal. per min. capacity. Water for boiler feed is treated with 2.2 lb. of soda ash per 10,000 gal. The soda ash solution is mixed in a tank in accordance with about what is expected in the way of load on the boilers. The control of the solution passing into the boiler feed is taken care of by manual control of the solution pump, which is checked by the number of inches per hr. which the soda ash solution tank drops in level.

As the water treatment has only been used for about a month, it has not been definitely determined as to

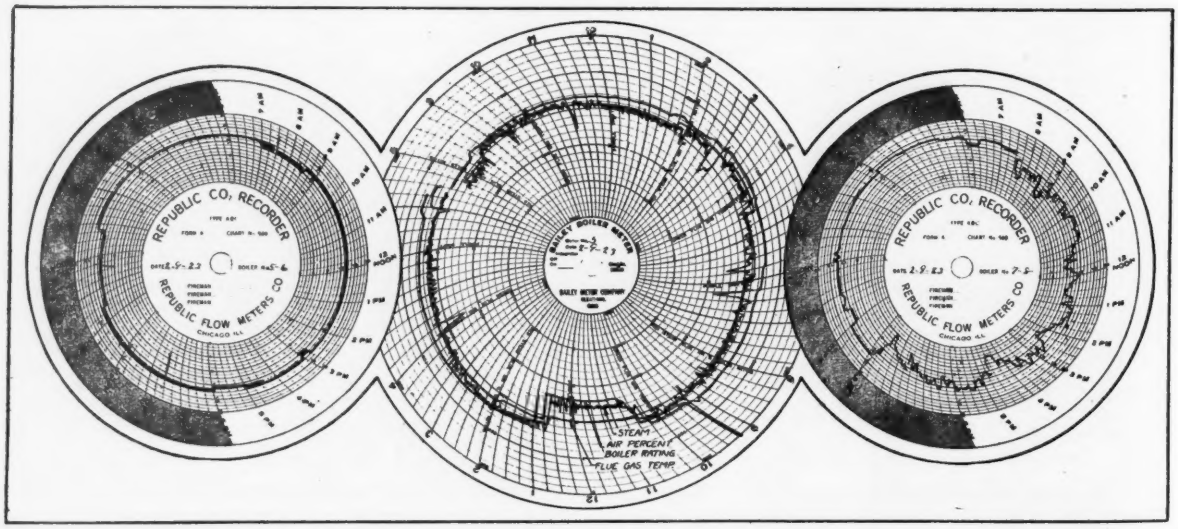


FIG. 6. IN DETERMINING THE AMOUNT OF AIR, ATOMIZING STEAM AND OIL, THE PERCENTAGE OF CO_2 IS USED AS A GUIDE

While the coal handling equipment is not in use at the present time, it is maintained in good condition so that it will be possible to go back to coal burning if it is so desired. As laid out, coal is received in dump bottom cars and then either piled for storage by two Orton-Steinbrenner cranes or passed through the C. W. Hunt two-roll crusher and then conveyed to the coal bunkers. There are two 2-T. C. W. Hunt weigh larries, one for each side of the firing aisle.

Ash disposal is taken care of by the use of tram cars under the ash hoppers, which are then dumped into the ash hoist and the ashes are hoisted to the bunker. From the bunkers ashes can be distributed into standard railroad cars. The capacity of this ash bunker is sufficient to fill a 50-T. coal car.

For supplying the draft when the boilers are stoker fired four Sturtevant fans are used. Three of these fans are driven by Westinghouse and Allis-Chalmers motors and one is driven by a Sturtevant turbine. The stokers are driven by four Sturtevant 6 by 7 in., 420 r.p.m. stoker engines.

Water Supply from Natural Pond

Water for boiler feed and also for process purposes in the dye works is taken from a natural pond about

what effect this will have on operation. As a matter of fact, not much trouble has been experienced at this plant, because the water is fairly good for boiler work.

Feed water is pumped to the boilers by four feed pumps, two of which are American Well Works centrifugal pumps of 350 gal. per min. capacity, operating at 3000 r.p.m. against a 600-ft. head, and are driven by Terry turbines. Another unit has the same capacity as the above pump but the pump is a Janesville centrifugal. The fourth unit is a 750 gal. per min. Janesville centrifugal, operating at 2600 r.p.m., 600-ft. head and driven by a General Electric turbine. For controlling the feed Copes regulators are used.

It is customary to clean the first drum every three months, as well as the tubes in the first bank. The entire boiler is thoroughly cleaned every six to nine months. The repair crew takes care of the boiler treatment, such as mixing up the proper amount of soda ash for 24 hr. operation. Two Cochrane open heaters are used for the feed water and are operated in parallel. During the summer months the feed water temperature is about 210 deg. F., while in the winter the temperature runs around 190 to 195 deg. F. on account of insufficient exhaust steam during the cold weather. This is partly due to the fact that ice machines are run at

greater capacity during the summer months. Exhaust from all of the auxiliaries, the refrigerating units and the compressors passes into the feed water heaters. No special method of heat balance is used, although at certain seasons of the year conditions are better than at other times.

The plant is located on the Delaware River at Deep Water Point, New Jersey, opposite Wilmington, Delaware. Oil is received by boat at the company's wharf and pumped into two 55,000-bbl. storage tanks by pumps located on the boat. At this oil pumping station there is a complete installation for Foamite fire protection equipment. From the oil pumping and storage station oil is pumped by two Dean steam driven oil pumps through a 6-in. line to two 50,000-gal. working tanks. It is possible, in 8 hr. of pumping, to furnish sufficient oil for operation of the boilers through the full 24-hr. period. At present the boilers are taking 1500 bbl. a day.

From the working tanks the oil is pumped by the Hammill oil pumps, of which there are four. Two of these are being used as spare units. The oil supply line for the boilers makes a complete loop under the firing floor.

In the turbine room there are four, 1500-kw., 3600 r.p.m., 2300-v. 3-phase, 60-cycle turbo-generators, two of which are Allis-Chalmers and the other two General Electric. All of the condensing equipment was furnished by Allis-Chalmers.

For purifying the oil a Bowser oil filter is used, although this is not of a continuous type. The oil is filtered every two or three months, depending upon operating conditions. The Allis-Chalmers turbines have and oil capacity of 60 gal. and a coil cooler is used. In the General Electric machines, however, the capacity is 30 gal. and no cooler is provided.

Excitation is supplied by two 50-kw., 3000 r.p.m., 110-v. General Electric generators driven by Terry turbines.

That section of the turbine room devoted to the air compressor and the ice machines is at the same level as the turbine auxiliaries and comprises about half of the floor area. There are six Ingersoll-Rand compressors with a total capacity of about 11,200 cu. ft. per min. The two ice machines are of 100-T. capacity each and both are supplied by the York Manufacturing Co., although one is driven by a York uniflow engine and the other by a Corliss engine. Refrigeration is used for process work in the dye works and also for manufacturing ice.

Current is generated at 2300 v. and feeds out of the main switchboard to a distribution tower. The plant distribution is at 2300 v. and is reduced to 550 v. for motor drive. There are four turbine panels, two exciter panels and one regulator panel and 11 distributing panels which go to make up the switchboard.

In the main pumping station which supplies water for process purposes there are nine centrifugal pumps, three of which are Lea high duty and one Allis-Chalmers, two American and three Worthington. The motors, which are Allis-Chalmers, General Electric and Westinghouse, are controlled from a central control board, as may be seen from Fig. 4E.

Boiler Room Costs Are Kept

In this plant considerable attention has been given to the subject of cost accounting and record keeping in order to check up on operation conditions. In Fig. 5 is shown the boiler house operation cost form which is used.

It will be noted that the costs are classified by groups and figured in three ways, namely, the cost per bbl. of oil fired, the cost per 1000 lb. water evaporated and the cost per boiler hp.-hr.

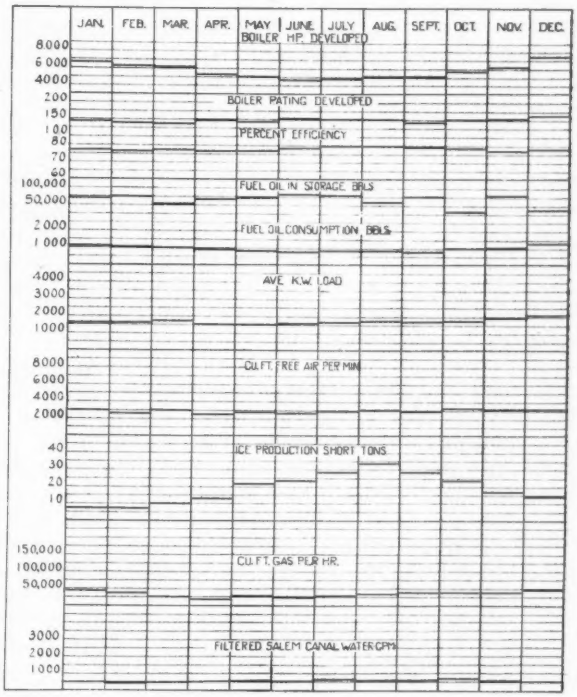


FIG. 7. AVERAGE DAILY OPERATING CONDITIONS FOR EACH MONTH ARE PLOTTED AND COMPARED FROM MONTH TO MONTH AND YEAR TO YEAR

In a recent month total fuel oil fired was 36,696.29 bbl.; total water feed to boilers, 165,296,465 lb.; total water blown down, including leakage, 1,116,400 lb.; total water evaporated, 164,180,065 lb., and the boiler horsepower-hours delivered was 5,256,000. The equivalent evaporation from and at 212 deg. in pounds of water per pound of dry fuel oil was 14.41 and the actual per cent of rating developed was 161. With an average B.t.u. per lb. of fuel oil fired of 17,950, the average boiler efficiency for the month was 77.9 per cent. The grand total of boiler room expense on a basis of boiler horsepower-hours was $0.007,735.

While at one time such costs were figured for the turbine room, boiler compressors and for the ice machines, this has been discontinued because of the reduction in clerical help. It is stated, however, that the boiler room costs are the most important, as it is usually possible to figure the cost per kilowatt hour, the turbine room expense remains fairly constant.

Operating Charts Are Found Valuable

Daily log sheets are kept of the boiler room turbines, ice machines and compressors, and the average operating condition for the day is plotted on the curve. From this curve it is possible to see any variation in

operating conditions, such as boiler horsepower developed, boiler rating developed, per cent efficiency, fuel oil in storage, fuel oil consumption, average kilowatt load, cubic feet fresh air per minute, ice production cubic feet of gas per hour made in the producer gas plant and the amount of water filtered. At the end of the month these average daily figures are again averaged, which gives an item of the average condition during the month. At the end of the year a chart is made up, such as shown in Fig. 8, which gives a summary of the year's operation.

According to Mr. Brown, this system has been found exceedingly useful in showing the variation in operating conditions. Frequently it is necessary to take up the question of making repairs or increasing the help, or any number of other such points, and the particular changes in operating conditions which have brought about such a condition. For instance, if it is shown on the daily record that the boiler rating has kept going up or there is an increase in the amount of compressed air used for process work, this may lead to a study of industrial work in order to determine whether all of such increases have been necessary. It is found that these daily charts are referred to frequently for a number of years back to determine just such points.

Although on the particular chart shown in Fig. 7, the boiler room costs are not presented, this curve has been found of value in showing immediately any increases or decreases in such costs. If the head of the power department has curves of this kind placed in a conspicuous point in his office, it is quite natural that he will have his attention constantly called to any seemingly unusual variation in operating conditions. In fact, it is quite possible to secure the interest of the entire power organization in cost work of this kind, and as Mr. Brown pointed out, the fixed costs have been reduced almost every month since this system was adopted. It is evident that such work is well worth the effort and the slight additional expense involved in its preparation.

Governors Urge Power Development

WORKING ALONG somewhat different lines for the development of electrical power which shall be generally available to small consumers of power as well as for electric lighting and electrification of street railways, Governor Smith of New York and Pinchot of Pennsylvania have requested the legislatures of their respective states to take measures looking to the conservation and utilization of such power at its sources and its equitable distribution for general use.

In a special message to the New York legislature on March 5, Governor Smith called for comprehensive action for developing the water power still available from the Niagara and St. Lawrence Rivers and transmitting it to municipalities for distribution at approximate cost of production and delivery. He recommended that the state engineer be charged with the duty of beginning development work at once, including preparation of plans and negotiations with the Federal Government. Pending the development, he asked that existing transmission lines be declared common carriers and subjected as such to regulation by the state, and that further permits or licenses for the development of water powers be immediately discontinued by the abolition of the Water Power Commission which is empowered to grant them. An appropriation of $75,000 was also requested, to cover expenses of the pending litigation against the Federal Government which seeks to annul the Federal Water Power Law and return to the individual states control over the water powers within their borders.

Recommended action by Governor Pinchot of Pennsylvania looks to a broad survey of fuel and water power resources available for use within the state, whether they be situated within the state or not. In calling for an appropriation of $35,000 to meet the expense of a preliminary survey of these resources and of the best means for making them available, Governor Pinchot made specific reference to development of Niagara Falls and other sources of water power outside the state. He said: "Such a survey should point out the way to secure for all industries, farms, homes and railroads in all parts of the commonwealth an abundant supply of cheap electric energy while duly safeguarding existing investments in the electric industry."

Plans advocated by Governor Pinchot would apparently call for the development of a superpower system to include the New England and North Atlantic States, with centers of production of power at the mines and water powers and high tension transmission to centers of distribution throughout the territory. It is therefore of considerably wider scope than the proposals of Governor Smith, and its author is directly opposed to the views advanced by Governor Smith in regard to the Federal Water Power Law. This was to be expected in view of Governor Pinchot's unswerving advocacy of the Roosevelt measures for conservation. In line with his opinion on this subject, he has written Governor Smith an open letter urging that the action of New York State against federal control of the water powers be dropped.

Water or Air Cooling

By W. F. Schaphorst*

ENGINEERS are sometimes asked and are unable to answer the question as to why condensers are water-cooled rather than air-cooled. It is argued that "air finally must absorb the heat anyhow, so why not air-cool the condenser in the first place?"

It is true that "air finally absorbs the heat anyhow," but the circulating water must first be sprayed into the air in order that its radiating surface may be made as large as possible to bring the temperature of the water down to the proper point again. What is more important, the temperature of the water is often brought to a point lower than the temperature of the air. Much depends upon the humidity of the atmosphere.

Air is not as good for cooling as is water. That is a well-known fact. Water is a better conductor of heat. Put your hand in air that has a temperature of 32 deg. and it won't feel so very cold. Then put your hand in water of the same temperature and it will feel cold. Why? Because water is the better conductor.

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Boiler Settings for Economical Steaming

MANY DETAILS OF THE BOILER SETTING INFLUENCE DIRECTLY THE HEAT ABSORBING CAPACITY OF THE BOILER AND THE EFFICIENCY OF COMBUSTION. THE AUTHOR GIVES SOME OF HIS THEORIES ON DESIGN IN THIS ARTICLE. BY ZUCE KOGAN

PRODUCTION of steam at the least expense is the main object that is required of the boiler plant. This question, however, embraces a great many conditions that must be carefully considered and successfully fulfilled. Generally speaking, the influencing conditions may be classified under two main divisions:

1. The operation within the boiler, i. e., the boiler and furnace proper, as for example to secure complete combustion, to utilize most of the heat of the gases in heating the boiler shell.

2. The operation outside the boiler, i. e., the accessories, as for example the economical working of mechanical stokers, forced draft fans, economizers, fuel and ash conveyors, etc.

Both of these factors have to be carefully considered, as both of them concern directly the steam generation. As a rule, however, it is always best to consider in a plant, the condition that affects the economy most, therefore in this article consideration is given principally the operation of the boiler proper as it will affect the economy of steam production more than the factors outside the furnace. The latter are but the accessories of the boiler plant and require only a portion of the steam generated, and therefore the possible gain in economy effected by them is but a portion of that possible with the boiler.

Boiler operation depends upon a great many factors such as draft, fuel beds, etc., and also on the adaptability of the boiler installation. Some of these conditions can always be regulated and changed to give highest economy even when the boiler is working, while the boiler installation or boiler setting cannot be changed without loss of time for reconstruction. For this reason first consideration will be given to the boiler setting mostly because it is an incontrollable factor that affects the internal working of the boiler and because its cost is high.

BOILER SETTING ACCORDING TO PHYSICAL LAWS

GENERALLY speaking, the question of steam economy as far as the boiler itself is concerned depends upon two main things:

1. The generation of greatest amount of heat from the fuel, which is the combustion process carried out within the furnace.

2. The transfer of greatest amount of heat from these burned gases to the boiler water.

These two distinct processes are considered separately by the modern designer. With a given grate and boiler the designer is compelled to confine his efforts to increase economy to arrangements of the boiler setting. These settings may be designed in hundreds of different ways while every design has a distinctive feature. Today our investigation and study of physical laws compels us to recognize that every square inch of brickwork may affect the economy of steam generation. The magnitude of this effect will depend on the position and arrangement of the brickwork setting.

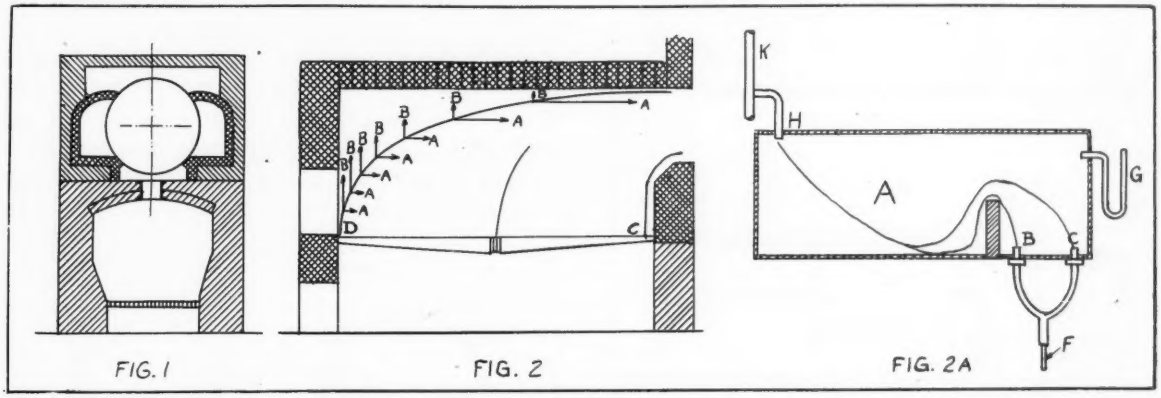

FIG. 1. SLOPING SIDES OF FURNACE ARE OF ADVANTAGE IN BURNING WOOD. FIG. 2. HEIGHT OF BRIDGEWALL INFLUENCES THE PATH OF THE FURNACE GASES IN ACCORDANCE WITH THE VECTOR DIAGRAMS. FIG. 2A. DEVICE TO DEMONSTRATE INFLUENCE OF BRIDGEWALL

Low grade fuels have been used more extensively of late years due to a better understanding of the effects of arches and other furnace arrangement on combustion. Even the utilization of the heat of the gases has been advanced by studying the different installations and the effects of the brickwork on the path of gases. This is true with all types of boilers, but specially so with fire tube boilers, where the bridgewall is found to influence greatly the effectiveness of the boiler heating surface. The position and arrangement of baffles in the water-tube boiler, the brickwork arrangement around the fire tube boiler, and the position of the flue gas outlet from the boiler to the stack all affect the absorption of heat by the boiler.

COMBUSTION CHAMBER

ECONOMY of steam generation depends upon two distinct processes: 1. The efficiency of combustion of the fuel and 2. The efficiency of heat absorption from the burned gases by the boiler. As far as the boiler installation is concerned, the first depends on the type of grate and the furnace brickwork arrangement while the second depends on the type of boiler and the boiler setting.

With all fuels, it is known that when a furnace arch is not provided above the grate the gases which are lib-

erated quickly from the heated green fuel are subjected to a draft which pulls them straight upward, thus being carried away before being mixed thoroughly with the air. These gases coming directly in contact with the boiler shell are easily cooled down while passing through the boiler, and thus have no more opportunity for getting to a sufficiently high temperature for ignition.

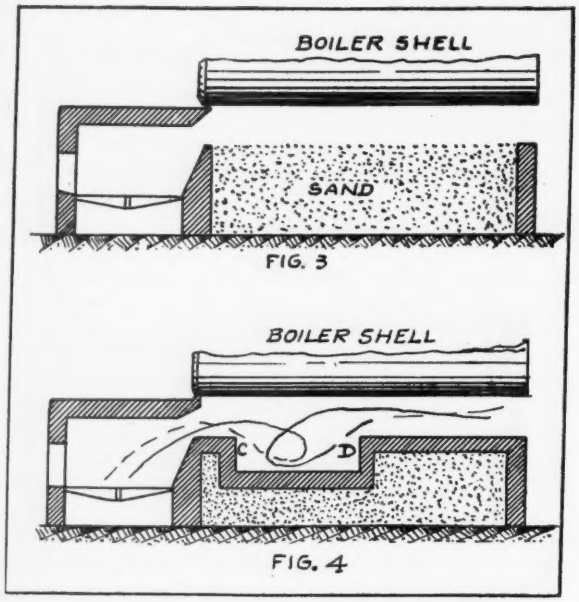

FIG. 3. FILLING SPACE BEHIND BRIDGEWALL FORCES GASES IN CLOSER CONTACT WITH BOILER SHELL

FIG. 4. BELATED COMBUSTION IS AIDED BY DEPRESSION BEHIND BRIDGEWALL

Moreover the flame coming in contact with the heating surfaces is easily extinguishable.

Taking this effect into consideration, we recognize the importance of using some kind of fire brick arch, especially above the green fuel where the gases are more quickly liberated than in other portions of the fuel bed which are always in an incandescent state. The gases rising against some arch meet the incandescent brickwork, which heats and ignites them instead of cooling them as when they strike the shell in which water is circulated.

Special designs are required for different boilers, grates and fuels; even sizes and shapes of fuels, as wood-sticks which are long and crooked, require special consideration. Wood-sticks, especially of crooked type, when placed on the grate do not cover it completely and leave a great amount of air to pass through, which results in poor combustion. This is a difficult problem, but some help is possible by arranging the side walls as in Fig. 1, in a tapered condition, in which case the wood-sticks, when burning decrease in size and are compressed together, thus keeping the grate more closely covered.

Heating of Boiler Shell

Heat transmission from the gases to the boiler water will depend to a great extent on the boiler setting. Such an installation may take into account a great many principles, such as the laws of expansion and contraction of gases at different temperatures, the path taken by the gases, etc. Things must be considered for their commercial value. Here we deal with steam generators that are to work constantly and therefore every slight advantage and economy gained, becomes great in value during the months or years of operation.

In designing the furnaces, however, we can always find it possible to arrange the brickwork setting in the most desirable way without any great difference in cost over a less efficient arrangement. It is therefore of great importance to consider all possible arrangements, even those that give the slightest effect on efficiency.

It is not practical to permit inefficient absorption of heat by the boiler surfaces in order that the heat may be used for other purposes, as heating the air or the feed water. It is undoubtedly advantageous to utilize the waste heat, but we want first to use all the heat possible in generating steam and then to take advantage of waste heat.

Close Contact of Gases with the Boiler Shell

Without doubt, when the hot gases are not held close to the heating surface of the boiler heat passes away un-

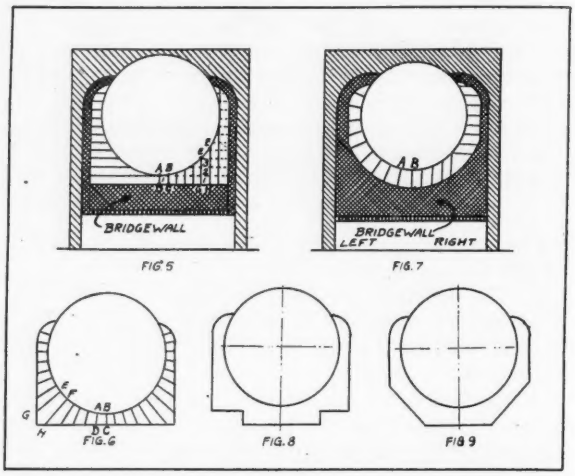

FIG. 5. SECTION OF GAS PASSAGE CROSSHATCHED TO ILLUSTRATE HEAT AVAILABLE IN GASES

FIG. 6. SECTION OF GAS PASSAGE DIVIDED RADIALLY

FIG. 7. BRIDGEWALL DESIGN FOR UNIFORM GAS DISTRIBUTION

FIG. 8. MORE HEAT IS GIVEN TO THE BOTTOM OF SHELL THAN THE SIDES WITH THIS FORM OF BRIDGEWALL

FIG. 9. PRACTICAL FORM OF BRIDGEWALL THAT APPROACHES THEORETICAL REQUIREMENTS

used. To prevent this loss, bridgewalls are provided in fire-tube boilers, baffle plates in the water-tube boilers, and the gas passages are carefully proportioned. The bridgewall with fire-tube boilers is not only for preventing the fuel from falling over the rear end of the grate, but is used to form a passage for the gases and to reflect heat on the fuel bed. The path of the gases through the setting is modified in two ways by the bridgewall; it causes a rising and falling of the gas particles as they pass longitudinally through the setting and also distributes the gas traversely across the setting.

Considering the modification of the longitudinal path of the gases by the bridgewall separate consideration

must be given to the parts of the combustion space in front of and back of the bridgewall.

In front of the bridgewall two forces are acting to direct the gases, one vertical, B, Fig. 2, the other horizontal, A. The bridgewall controls the horizontal force reducing it, for example, to zero at C, again at D the horizontal component is small and the vertical great in comparison. As the gases travel from the grate the vertical forces become smaller and the horizontal greater so that the resultant path of the gases is a curve. Thus by increasing the height of the bridgewall the gases rise more nearly vertical from the grate and will impinge more directly on the arch.

As the gases pass over the bridgewall, they are deflected downward due to the abrupt increase in area of the gas passage. In order to prove that the gases are actually deflected the author constructed the apparatus shown in Fig. 2A. The smoke box A is attached to a pump K while the apertures B and C are attached with rubber tubing and pinchcocks to a Y tube. A cigarette F is inserted at the end of the Y tube and a U gage at G is attached to the smoke box to show the draft.

This apparatus showed that the smoke did deflect downward after passing over the bridgewall. It was also noted that by inserting a compactly filled cigarette the resistance was high at the entrance and the deflection was increased; a loosely filled cigarette gave the reverse effect. It was also noted that there was a difference in deflection of the gases entering at B and C. This may be due to the difference in distance between C and H, and B and H.

This influence is of great importance with wood burning furnaces where the high fuel beds require high bridgewalls. The higher the bridgewall the greater the deflection that takes place. It is for this reason and the higher pressures that are maintained in wood burning furnaces, that the author is of the opinion the gases do not hug the boiler shell closely and the efficiency of steam generation is low. One remedy for this is to make the arch long extending the whole length of the boiler shell or as in Fig. 3 where the whole space under the shell is filled with sand. In this case the gases are obliged to be kept more closely in contact with the shell due to the restricted passage. Combustion in this case must be completed in the space in front of the bridgewall. Unfortunately this is not always possible as even with a good furnace design we may expect some unburnt gases at the bridgewall which are apt to be consumed during their path.

With the Dutch oven type of furnace we find that with some fuel and furnace conditions combustion takes place at the rear end of the boiler. Complete combustion is not likely to take place in such a restricted passage nor will the air be able to mix properly with the gases in such a passage and therefore it is desirable to design this bridgewall with an increased gas space. The arrangement shown in Fig. 4 is found advantageous in this case, where C D is made to give the gases the necessary chance for mixing and burning. In this drawing, two paths of gases are shown, one being straight and the other in the form of a loop, and it is the latter path that usually helps the fuel to mix with the air satisfactorily. The deeper this impression, the better the mixing and it is therefore of value to make this more than a foot deep. The depression C D will enlarge the furnace for a foot or two while the rest holds the gases in close contact with the shell.

Considering the effect of the bridgewall on the path of the gases around the shell, this will depend on the section of the gas passage or the form the gases take between the bridgewall and boiler shell. This section may differ as shown in Figs. 5 to 9, in which cases the effect may depend upon the particular installation. Generally speakng, it may be said that as far as the heating efficiency is concerned, the shape of the bridgewall does not have any great effect when the bridgewall is but a few inches in thickness, but is of importance with those bridgewalls that extend through the whole length or the greatest portion of the length of the boiler shell.

In order to investigate theoretically the influence of these different shapes of long bridgewalls, let us take an example where the area of the gas passage is just the size necessary to give proper velocity to the gases. Supposing that each square foot of heating surface of the shell is covered with a number of layers of gases, each area or portion of shell will be in contact with a quantity of gases according to the number of layers or volume of gases under this portion of the shell. Furthermore, let us assume that each unit section area of gases contains a given amount of heat. In this case volume of the gases under a given portion of the shell will represent the total amount of heat available to heat this portion of the shell, therefore if we will assume for the moment that the heat in the gases travels upward only and the sectional area is divided in layers parallel to the vertical axis of the shell as shown in Fig. 5 (in which case each square represents one given volume of gases or given number of heat units) then by comparing the surface AB with EF, we find that the former has a certain amount of available heat underneath it while the latter, which is only 1½ times the length of the former, has 3½ times as much available heat. This shows that the portion of heat under the shell is greater at EF than at AB with the bridgewall-shape shown in Fig. 5 This leads to the conclusion that with such a shape of bridgewall the amount of heat for heating the part AB is insufficient due to the fact that AB, being the lowest portion of the shell and therefore containing the coldest water needs more heat than the part EF.

Considering that heat is carried from the gases perpendicularly to the shell, as shown in Fig. 6, then again the amount of heat carried to each unit area will be less at AB than at EF.

In Fig. 7, the bridgewall, being circular, distributes the gases uniformly over the whole portion of the shell. Even if this is true, the uniformity of gases will still not answer the requirements for a greater proportion of heat at AB. In order to fulfill the latter, Fig. 8 is a more suitable shape. Figure 9 seems to be one of the most suitable designs to give proper distribution of heat around the shell, thus supplying a greater amount of heat to the lower portion of the shell.

In designing baffles for water-tube boilers we have to consider that the gases take the shortest possible path and will therefore choose the path shown by the full line instead of that shown by the dotted line with the arrangement shown in Fig. 10, thus leaving a great portion of the tube inactive as it is out of the stream of the hot gases. Another point to be considered with the question of keeping the gases in close contact with the boiler shell, which is equivalent to having a high veloc-

ity of gases sweeping the heating surfaces, is the reduction of volume of the gases. The gases in the furnace are of high temperature, therefore contract when coming in contact with the heat absorbing surfaces of the boiler shell. Therefore in order to maintain constant velocity of the gases through the boiler setting a reduction in section of the gas passages is required as reduction in volume takes place. Considering this, we know that the first pass of gases from the fuel bed gives the greatest fall in temperature and therefore the greatest reduction in volume. For this reason, the decrease in sectional area of gas passage must be greater in the first pass of gases than in the second or third passes. This may be accomplished by having the first baffle plate well inclined towards the front as shown in Fig. 11.

Referring, however, to the fire-tube boiler, the reduction of volume of gases as they pass under the boiler shell is seldom considered although it has been found by the users of long bridgewalls that there is an increase in efficiency by installing the boiler in the manner shown in Fig. 12. In this case, the section of the gas passage is reduced as the gas passage increases the length. This practice is justified as the difference in gas temperature between the ends may be about 1500 deg., which necessarily results in a great reduction in volume of gases.

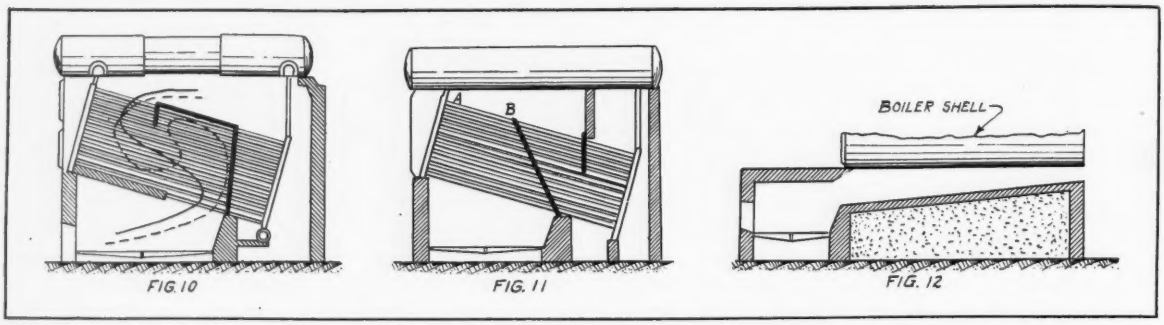

FIG. 10. POORLY DESIGNED BAFFLE ARRANGEMENT THAT GIVES DEAD SPACE IN BOILER. FIG. 11. SLOPING BAFFLES ELIMINATE DEAD SPACES AND GIVE UNIFORM GAS VELOCITY THROUGH SETTING. FIG. 12. RETURN TUBULAR BOILER WITH GAS PASSAGE DESIGNED FOR UNIFORM VELOCITY

Exposure of Shell to the Gases

Next to the close contact of gases with the shell, the nature of exposure of shell to the gases is the question governing the efficiency of heating the boiler shell. The amount of exposure will generally depend on two things: 1. The heating surface of the boiler shell utilized. 2. The time the gases are in contact with the shell.

Heat of the gases is given up to the boiler surface with which it comes in contact and it is therefore important to have the largest possible contact for the given boiler. The idea of designing boilers with a number of tubes was to increase heating surface and therefore the installation of boiler setting must also be designed with this object in view. Taking examples as shown in Figs. 13 to 16, we find that with these flue-tube boilers we can expose their surfaces to the gases in many different ways. Of these cases the surfaces are exposed more completely in Figs. 14 and 16 than in the others. The hot gases not only generate the steam but superheat it to some extent thus utilizing these gases over practically the entire surface of boiler shell. This is advantageous as far as the heating surface is concerned but its practical adaptability will depend on certain conditions.

We occasionally find that with some fire-tube boilers, especially those equipped with Dutch oven type furnaces, the furnace shell is installed too far forward, i. e., extending out too far from the front of the setting or the arches are extending to some length under the boiler shell and this is very impractical. If the heating surface of the boiler is too great, then this is not a disadvantage. If the Dutch oven type arch has to be longer, why place it under the boiler shell? It is better to extend the furnace.

The Time of Exposure

Increasing the length of the path for the gases through the setting increases the time the gases are in contact with the boiler shell. This is a question of great importance, as it gives to the water within the shell more opportunity to absorb heat from the gases. This is most easily done with water-tube boilers where the number of passes for the gases to travel depend upon the number and arrangement of baffle plates. In order to lengthen the gas passage with fire-tube boilers, we may employ the arrangements shown in Figs. 13 to 16. In Fig. 13 the gases are making only two passes, one outside the boiler shell and one inside the fire-tubes, which is one of the old types of flue-tube settings. In Figs. 14 and 15 the gases pass over the heating surfaces three times, twice around the boiler shell and once within the fire tubes. Figure 16 shows an arrangement for passing the gases over the heating surfaces four times and is perhaps the most practical arrangement with the water-tube boiler.

Comparing the Surface with Time of Exposure

It is always impractical to consider only one point in the design when this point has some relation to another. We cannot in this case consider the heating surface and the time of exposure separately. For considering these four figures, we find that in comparing Fig. 13 with Fig. 15 and Fig. 14 with Fig. 16 we have equal surfaces of exposure, but the times of exposure are different. On the other hand, Fig. 15 in comparison with Fig. 14 has the same time of exposure while the surface of exposure differs. Even if we compare Fig. 13 with 14 and 15 with 16, we still find that the number of paths are not directly proportional to their heating surface. For this reason, with a certain

boiler installation these two questions of time and surface generally vary indirectly one with the other and the proper choice of arrangement must be carefully considered.

If, for example, we would consider Figs. 14 and 15, which have different surface exposures but same lengths of gas passages, we find that Fig. 14 is to be considered preferable of these two because it has, with the same number of passes, a greater heating surface, but Fig. 15 gives better absorption of heat because the three passes are in contact with the water heating surfaces, while one pass of Fig. 14 has a superheating effect. The water being colder and in constant circulation makes the time in heating it of greater value than when heating steam, therefore Fig. 15 is better or more efficient in absorbing the heat, regardless of the fact that the surface of exposure is greater in Fig. 14. From another point of view, we find that for a given time of exposure the surface of exposure is too great in Fig. 14 and this may sometimes prove dangerous. Should the furnace in this case be operated at high rating and the boiler tubes covered with scale that acts as a bad conductor, then the gases passing the shell and coming in contact with the portion of shell not covered with water may overheat it to a dangerous degree. The arrangement shown in Fig. 16 gives a lower temperature to the gases that superheat the steam, thus avoiding the dangerous arrangement shown in Fig. 14.

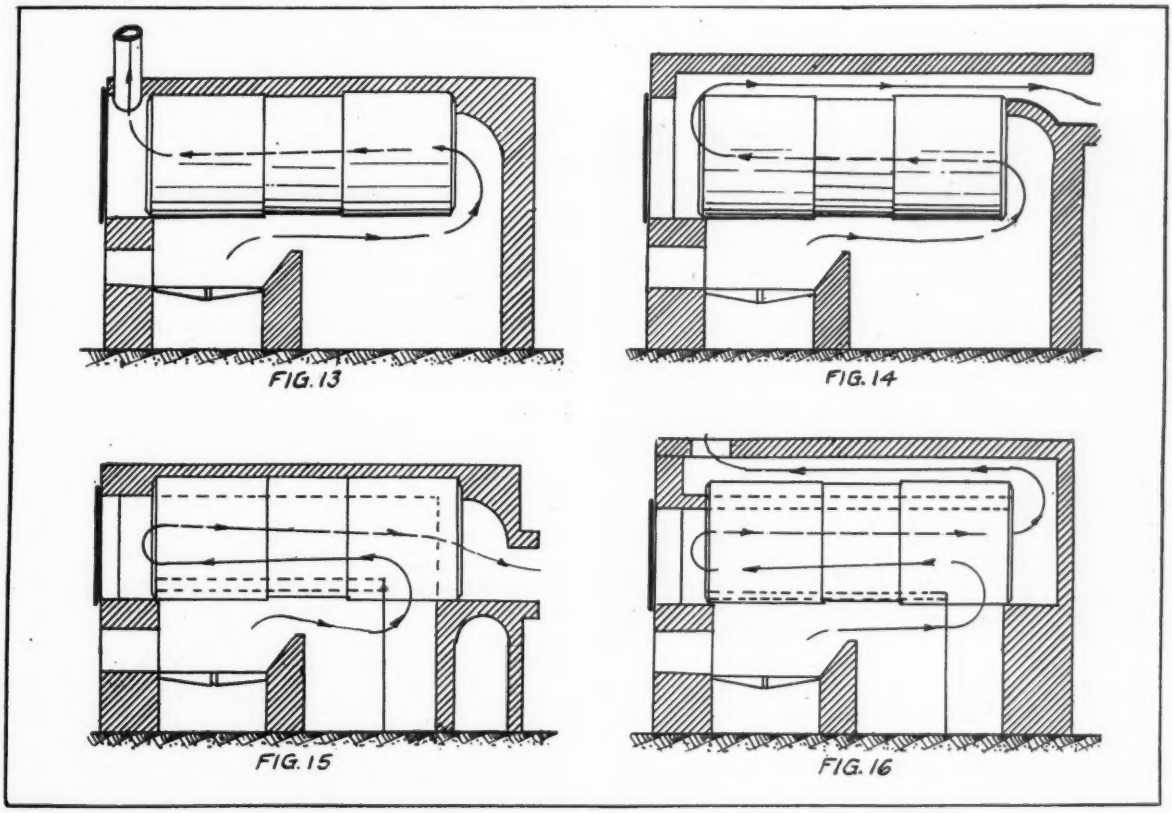

FIG. 13. TWO PASSES ARE PROVIDED FOR THE GASES IN THIS COMMON TYPE OF RETURN TUBULAR BOILER SETTING. FIG. 14. THIS THREE-PASS SETTING SUPERHEATS THE STEAM. FIG. 15. WITH RETURN PASSAGES ON THE SIDES OF THE SHELL GASES ARE IN CONSTANT CONTACT WITH WATER HEATING SURFACES. FIG. 16. FOUR PASS SETTING SUPERHEATS THE STEAM

Steaming Tests of Alaskan Coals

RESULTS OBTAINED from a series of steaming tests of certain Alaskan coals conducted at the Alaska experiment station of the Bureau of Mines at the Anchorage power plant of the Alaskan Engineering Commission are given in Serial 2412, recently issued. The fuels tested were lignite from the Nenana field in the foot hills on the northern slope of the Alaska range and bituminous coal from the Matanuska field, which lies between the Chugach and Talkeetna Mountains in the valley of the Matanuska River. The only coal mine at present in operation in the Nenana field is that of the Healy River Coal Corporation, near Healy station on the Government railroad, 244 mi. from Anchorage. The principal commercial mines of the Matanuska field are those of the Evan Jones and Baxter coal companies, 58 and 55 mi. respectively from Anchorage. Serial 2412 may be obtained from the Bureau of Mines, Washington, D. C.

RECENTLY THERE was discovered in a small plant in Fairport, N. Y., a boiler having neither safety valve nor water gage. The existence of such an outfit in a populated community scarcely requires any comment, but it would seem to indicate that the State of New York is badly in need of a license law.

R. G. SUMMERS.

Handling Bulk Quantities of Fuel Oils

PIPING ARRANGEMENTS, HEATING, PUMPING AND MEASURING FACILITIES THAT HAVE PROVED SUCCESSFUL. BY ROBERT JUNE

RIGHT at the outset, let us define the term "bulk" used in the title of this article, as referring to conditions where the equivalent of one or more tank cars must be handled within a 24-hr. period, and let us assume that storage facilities have been provided, so that we are concerned only with the details of handling.

Tank cars from which we receive our oil have capacities ranging from 7000 to 12,800 gal., depending, of course, upon their size. Standard equipment for such cars consists of 4-in. discharge pipes, located in the center of the car and controlled by a valve, the stem of which extends to the top of the car. Where gravity discharge is possible, it is desirable to place 10-in. pipes in a vertical position in the center of the rails and discharge the oil through these pipes into the storage tank. If several cars are customarily received at the plant at the same time, it may be well to put in several of these pipes, in which event they should be arranged with 43-ft. centers, as this is the length of the most commonly used tank cars. Threaded, or flanged caps, preferably threaded, should be provided for the 10-in. pipes, when not in use. The 4-in. discharge pipes of the car can be located directly over the 10-in. pipe with the result that when the car is properly heated, its contents may be discharged in one-half to three-quarters of an hour.

FIG. 1. ELECTRICALLY DRIVEN OIL PUMPS REDUCE TIME FOR EMPTYING TANK CARS

It is not customary to provide a strainer at the point of discharge from the tank car. The 10-in. line should have a gate valve at the entrance to the tank or at the entrance of each tank, if branches are provided to more than one tank. As a matter of safety and also to comply with the insurance rules of some states, the filling pipe should enter the tank near the bottom, thus providing an oil seal which will prevent the possibility of any gas within the tank being ignited by means of flame carried through the 10-in. line.

Where permanent gravity and discharge facilities, such as have just been described, cannot be installed, the alternative is to provide flexible hose which can be attached to the discharge pipe. Where a 3-in. hose is used and reliance is placed on gravity discharge, it will ordinarily require 3 or 4 hr. to empty the car. When time is an object, in that labor may be saved and the cars unloaded more rapidly and where it is necessary to clear the right of way, it will ordinarily be found more profitable to pump oil out of the car than to rely on gravity feed. Thus, with a small rotary pump the contents of the car may be discharged in half an hour, where 3 or 4 hr. are required, as noted, where gravity alone is relied upon.

In Fig. 1 is shown an installation of electrically driven rotary pumps for removing oil from tank cars.

Of course, where storage tanks are located above the tank cars, it is necessary to resort to pumping. For this purpose, a rotary pump with 3½-in. connection is recommended. Such a pump will deliver 200 gal. per min., with a suction lift of 18 ft. against a maximum pressure of 75 lb.

GAGING THE OIL

PROBABLY the handiest method of determining the quantity of oil delivered is to gage the receiving tank. Before this can be done, the actual capacity of the tank for different levels will have to be accurately ascertained, either by placing known quantities into it or by making accurate measurements and then calibrating the gage. After this has been done, a schedule must be worked out, showing the capacity of the tank with oil at varying temperatures.

Oil, if purchased by the gallon, should be specified as being delivered at a pre-determined temperature, say 68 deg. F. Now, if the oil is actually loaded into the tank at this temperature and the discharge at the same temperature, there will be no discrepancy in the measurement; however, if it should be loaded in at 120 deg. F., and taken out at 68 deg. F., there would be a marked discrepancy. Conversely, since oil is bought on a basis of 68 deg. F., it will not do to measure it upon receipt at 120 deg. F. Therefore, if the oil is preheated, the discharge temperature in the receiving tank should be noted and due allowance made for expansion.

It is poor practice to undertake to measure the quantity of oil in a tank by means of a float connected to a chain extending over a pulley and connected to a counterweight sliding on a graduated scale. This arrangement does not come within satisfactory limitations and it possesses the great objection of providing a vent pipe, thus creating a dangerous fire hazard. Insurance companies generally object to such construction and specify that there shall be at least a screen, made of fine wire gauze, placed in the pipe to prevent the flame from passing through. It is best, however, to avoid this type of construction entirely and to use a con-

necting gage which does not require any permanent direct connection with the atmosphere.

It is, of course, necessary to heat heavy oil whenever it is moved. This means that storage tanks may be equipped with heating coils. Where tanks are located above the ground, the area of the heating coils will be largely determined by the climate. Where tanks are buried, approximately 35 ft. of ¾-in. steam pipe should be provided for each 10,000 gal. capacity.

Quite a common mistake is to bring oils to too high temperatures when endeavoring to move from storage. This should be avoided because it wastes steam and therefore fuel, unnecessarily, and it does not make oil any easier to handle above a certain point. Should there be any water in the tank, as frequently happens, it may produce steam bubbles in the oil, causing foaming. A good average safe temperature for handling oil out of storage is 125 deg. F. In laying out steam lines, provision should be made for a ¾-in. line to the tank car.

Pumps for Oil Service

Rotary pumps are in use by thousands for handling oil and their popularity is well deserved. The rotary pump has so frequently demonstrated its advantages over the piston pump for this same service, that it is hardly necessary to describe at length the different actions of these two principles. Suffice to say that the rotary pump will handle a larger volume of liquid with less power than the piston pump. This is so because the action of the rotary pump is continuous.

When once started there is no stop or hesitation in the flow of liquid, whereas in reciprocating pumps, when the piston has reached the end of the stroke, it stops and with it stops the flow of liquid. It is a well established fact that it takes more power intermittently to start the movement of anything than it does to keep it moving when once started.

Three advantages of rotary action are: 1. Continuous flow, with greater pumping volume. 2. Saving in power, with consequent reduced cost of operation. 3. Less slippage.

In Fig. 2 is illustrated a typical rotary pump. It will be noted that the buckets are hung in the rotor in such a way that they ride in the cylinder wall with extremely light contact, similar to a balanced flange valve on a steam engine. An important feature of this action is that the buckets take up their wear automatically, thus making a perfect seat on the cylinder wall at all times. The rotary pump, having a piston suction, need not be primed.

Revolving with the shaft, the piston causes the buckets to hold out against the cylinder by centrifugal force and gravity. This exhausts the air from the suction line, allowing the atmospheric pressure to force the oil into the pump and fill the extension chamber. The oil is forced out of the discharge as it cannot carry by the discharge port, owing to the fact that the only oil that will carry by is that which fills the recesses in the piston and this acts as an oil packing, keeping the pump at all times suction tight.

Piping Systems

Where heavy oil is to be burned as fuel in boilers, special attention must be paid to the design and layout of the piping system between the tank and pumps, and between the pumps and the burners. All of the pumps should be located as close to the tank and, at the same time, as close to the floor as possible in order to reduce friction and suction lifts.

At least half an inch larger pipe should be used for the intake line than the pump suction. The use of elbows should be avoided, long sweep bends being used in their places. Where the intake pipe lines lie along level ground for some distance, it should be installed with a slope upwards of about one foot in one hundred, toward the pump. Care should be taken to see that pipes are placed either in dry, well drained ground, or in equally well drained wood or concrete trenches.

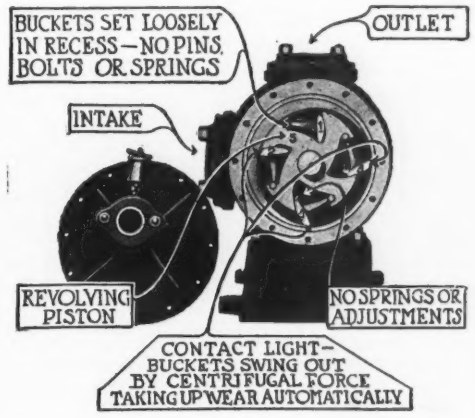
BUCKETS SET LOOSELY IN RECESS—NO PINS, BOLTS OR SPRINGS
OUTLET
INTAKE
REVOLVING PISTON
NO SPRINGS OR ADJUSTMENTS
CONTACT LIGHT—BUCKETS SWING OUT BY CENTRIFUGAL FORCE TAKING UP WEAR AUTOMATICALLY

FIG. 2. SECTIONAL VIEW OF ROTARY PUMP SUITABLE FOR HANDLING FUEL OIL

In the northern states piping subject to frost should be insulated. Discharge pipes from pump to burner should also be insulated.

It is quite frequently the practice to place a small live steam line inside of the discharge line to supplement the oil heater. In such cases, expansion at the point where the small line is introduced is taken care of by provision of stuffing boxes. By putting in this small steam line, it is possible to heat the oil in the discharge line when starting up a cold installation. This is an important point, as it greatly facilitates handling the heavy oil. Another piping detail which will greatly facilitate handling, is to run a circulating line from the far end of the discharge heater back to the suction tank. This makes it possible to circulate oil entirely through the system, in advance of firing the boilers—quite an advantage with heavy oils.

For piping of this sort, standard weight pipe and fittings can be used. Real care, however, should be exercised in selecting the valves, as cheap valves have a great tendency to leak.

In putting in piping for oil, joints should be made up with compound not affected by oil. For this purpose a mixture of litharge and glycerine is frequently used. To secure best results, however, this combination should be mixed in small quantities and used as rapidly as mixed, for the reason that it sets quickly and is, of course, of little value if the thread is not screwed on and the joint made before the compound has hardened.

Use of Air-Steam Mixtures Increases Efficiency

EXPERIMENTS CONDUCTED AT THE UNIVERSITY OF ILLINOIS INDICATE GAIN IN ECONOMY BY USE OF AIR-STEAM MIXTURES. BY L. A. WILSON AND C. R. RICHARDS

IN REVIEWING the history and development of steam engineering, we find that the use of air and steam combined as a medium for developing power is not of recent origin. The value of air in preventing rapid condensation of steam was known by Savery and other scientists before 1800 and was utilized by them in the operation of water pumps by interposing a layer of air instead of piston between the steam and the water.

In 1873, Osborne Reynolds of Cambridge, England, made an investigation to ascertain the effects of a small quantity of air on the power of a cold surface to condense steam. Reynolds reached the following conclusions:

(1) A small quantity of air in steam greatly retards condensation upon a cold surface. On the other hand, there is no limit to the rate at which pure steam will condense, except the power of the surface to carry off the heat.

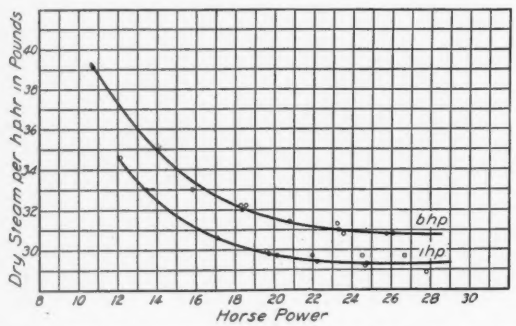

FIG. 1. STEAM CONSUMPTION PER HP.-HR. USING STEAM ALONE

(2) The rate of condensation diminishes rapidly and nearly uniformly as the pressure of the air increases from 2 to 10 per cent of that of the steam. It then diminishes less and less rapidly until a pressure of 30 per cent of that of the steam is reached, when the rate of condensation remains nearly constant.

(3) In consequence of this effect of air, the necessary size of a surface condenser for a steam engine increases rapidly with the quantity of air allowed with it.

(4) If air is mixed with steam before it is used, the condensation at the surface of a cylinder may be greatly diminished, consequently the efficiency of the engine is increased.

(5) The maximum effect in diminishing condensation will be obtained when the pressure of the air is about one-tenth that of the steam, or when about 2 cu. ft. of air at atmospheric pressure and with a temperature of 60 deg. F. are mixed with each pound of steam.

Perhaps the most potent cause of the reduced condensation of steam when mixed with air is the separation of the molecules of the steam by the molecules of the air. Evidently there can be no condensation of the steam unless its molecules coalesce; furthermore, the steam when mixed with air is converted into superheated steam and, therefore, recedes from the condensation point.

ATTEMPTS TO USE AIR-STEAM MIXTURES IN ENGINES

THERE APPEAR to be two general classes of air-steam engines hitherto invented, depending upon the method of providing a mixture of air and steam. In one case, the mixture is formed within the boiler; while in the other, the air and steam are mixed at or near the engine. The first method involves such means as the following:

(1) Injecting the hot gases from the chimney or uptake into the boiler under pressure.

(2) Operating the furnace under a pressure sufficiently high to force the gaseous products of combustion into the boiler without compression.

(3) Forcing air into the boiler to mix with the steam.

By any one of these means, energy is required to pump or inject the air or gases into the high pressure steam. The device used for this purpose has been an injector, a pump connected to the engine, or a pump driven independently.

Various attempts were made to put air-steam mixtures to practical use at various times. In 1870, a plan of providing a mixture by forcing high temperature air into the boiler from coils of pipe in the hot flue was given a great deal of publicity. This plan, which finally became known as Warsop's System, was adopted by the Lancashire and Yorkshire Railway, and also installed successfully in several vessels. It was reported that 10 or 12 per cent of air in the mixture gave best results.

Andrew Jamieson, at a meeting of the institution of Engineers and Shipbuilders, held in Scotland on April 30, 1895, read a paper entitled "A New Departure in Steam Engine Economy, with a Detailed Description of Tests of Field's Steam and Hot Air Engine." The tests of this engine showed a saving of 40 per cent.

Many other attempts were made along this line, but a detailed description of them cannot be given in this article. Enough has been said, however, to show that the idea is not new and to indicate to some extent the purpose of the detailed tests herein described.

This investigation of air-steam mixtures is an outgrowth of an investigation of the reheating of compressed air by C. R. Richards and J. N. Vedder, the results of which have been presented in Bulletin 130 issued by the Illinois University Experiment Station. In this earlier investigation, the employment of steam as a reheating agent was found to result in an increased thermal efficiency for the mixture of air and steam, as compared with the use of either air or steam separately, in an engine operating expansively. These results were such as to justify a further study of air-steam mixtures.

TESTS WITH STEAM, AIR AND AIR-STEAM MIXTURES

SINCE THE purpose of these tests was to determine the possible advantages in thermal efficiency resulting

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from the use of different mixtures of steam and air, over the use of steam alone, it was first necessary to determine the engine economy when using steam or air alone.

In testing with steam a gage pressure of 100 lb. per sq. in. was used and steam consumption was determined at different loads. The quality of the steam was determined by means of a throttling calorimeter located just above the throttle valve. All observations and indicator diagrams were taken every five min. during 30-min. tests. The results of the steam tests are represented graphically in Fig. 1.

Tests with Air

These tests were made to determine the air consumption at different loads for different initial air temperatures. The water vapor in the air froze in all tests made with air which had a temperature of 300 deg. F. or less. In every test in which the exhaust temperature was below 32 deg. F., the exhaust valve clogged with ice. When the back pressure caused by the stoppage became appreciable, the test was terminated.

All tests were started with the engine comparatively warm, and only data and indicator diagrams secured during the last 30 min. of a test were used. This practice was adopted to obtain data representative of normal running conditions. It was found, however, that owing to increasing friction in the engine caused by the formation of ice and from less effective lubrication, the mechanical efficiency decreased as the test progressed. It was impossible to get satisfactory equilibrium conditions with air alone except by heating the air to an initial temperature sufficient to prevent the exhaust temperature falling below 32 deg. F. By taking indicator diagrams and Venturi meter data simultaneously at stated intervals, under the conditions named, and computing the air consumption per indicated horsepower per hour, this was found to remain practically constant throughout the test. The air consumption per brake horsepower per hour varied for the reasons already stated; therefore, for these tests it has been averaged for the 30-min. period.

Tests with air were made at several loads with an initial gage pressure of 100 lb. per sq. in. at the throttle, and with initial temperatures of approximately 100, 200, 300 and 400 deg. F., respectively, at the entrance to the mixing chamber. When air was used the engine would not carry over-loads satisfactorily, probably because of the small size of the supply pipe and the consequent drop in pressure accompanying a late cutoff. The conditions of operation were such as to prevent the formation of a loop at the toe of the indicator diagram; hence complete expansion to back pressure determined the limit of earliest cutoff.

During the air tests the condenser was disconnected, the air being exhausted directly into the room. A pentane thermometer reading in degrees centigrade was placed in a mercury well as near the cylinder as possible to indicate the exhaust temperature. Air pressure was set at 100 lb. per sq. in. gage and kept constant by regulating the pressure of the steam operating the compressor. A preliminary run of 2 or 3 hr. duration was necessary to heat the pipes and enable adjustments of apparatus, particularly of the reheater, to be made; during the run sufficient steam was allowed to mix with the air to prevent freezing. Between runs it was necessary to pass steam through the engine to thaw the ice before making adjustments for the succeeding run. Before a test was started the steam was shut off by closing the steam valve tightly with a wrench, in order to eliminate the possibility of leakage since the introduction of a very small quantity of steam would lead to erroneous results. The results of the air tests are shown graphically by the curves in Figs. 2, 3 and 4.

It will be noted that some of the points do not fall upon the curves selected, for which fact the following explanation is offered. Variations in the initial air temperature existed, since it was impossible always to keep this temperature constant. For some tests the average temperature fell above or below the desired value, in which cases the curve was made to pass at the proper distance from the point recorded. Three such points appear on the curve which records temperature of 100 deg. F. The points for air at 200 deg. are somewhat

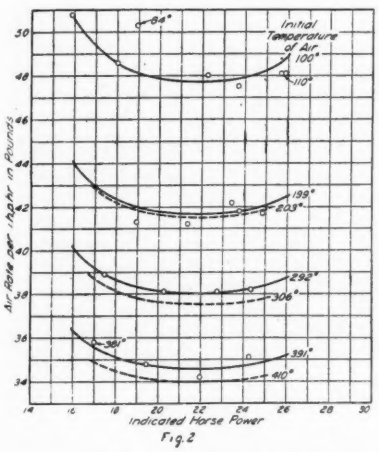
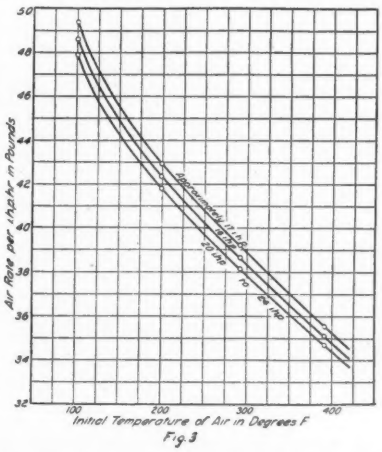


Fig. 2


Approximately 11 Lb. Air per I.H.P. per Hr. for 20 HP to 64 HP
Air Rate per I.H.P. per Hr. in Pounds
Initial Temperature of Air in Degrees F
Fig. 3

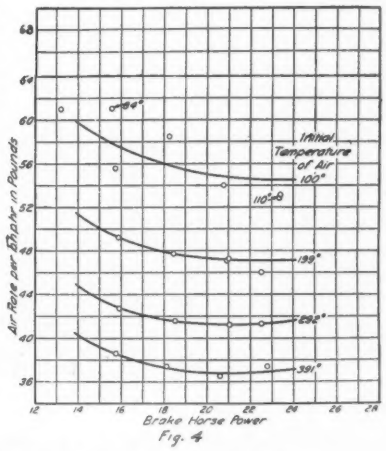


Fig. 4

FIG. 2. AIR CONSUMPTION PER I.HP. PER HR. FOR DIFFERENT INITIAL TEMPERATURES, USING AIR ALONE
FIG. 3. AIR CONSUMPTION PER I.HP. PER HR. FOR GIVEN HP. FOR DIFFERENT INITIAL TEMP., AIR ALONE
FIG. 4. AIR CONSUMPTION PER B.HP. PER HR. FOR DIFFERENT INITIAL TEMPERATURES, USING AIR ALONE

scattered, hence the curve was drawn to make it consistent with the three other curves.

These curves show that with compressed air the greatest economy was secured at approximately 22 indicated horsepower, which is somewhat lower than that for the greatest economy with steam as the working medium.

Tests with Air-Steam Mixtures

After the usual preliminary period of adjustment of apparatus, each test with mixtures of air and steam was continued for one hour. A pressure of slightly more than 100 lb. gage was maintained in the steam main, the amount of steam to the engine being controlled by an auxiliary valve located near the mixing chamber. The amount of air was regulated by throttling the air compressor. It was found that the proportion of the mixture could be judged and regulated fairly accurately from observations of the temperature just below the mixing chamber. The actual temperature of the mixture at that point proved to be practically identical with the theoretical temperature, where the initial temperatures of the air were 100 and 200 deg. For higher initial air temperatures, however, the actual temperature of the mixture fell slightly below the theoretical, probably because of increased radiation losses at these higher temperatures.

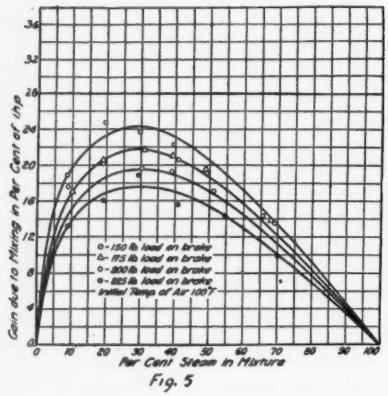
The weight of condensed steam was taken at the end of each run. It consisted of the water coming from the condenser, together with that carried by the saturated air exhausting from the condenser and that separated by condensation in the mixing chamber, resulting from heating the air in the tests in which air at a temperature below that of the steam was used. The first and the last of these quantities were obtained by weighing; whereas the amount of water carried off by the air was computed from its temperature and pressure.

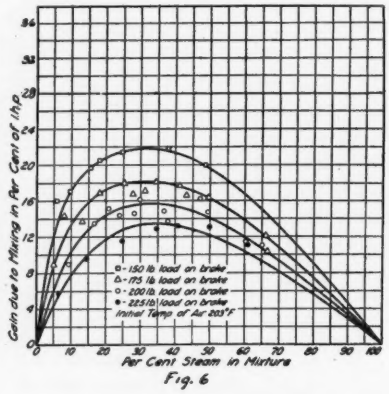
High-pressure air was comparatively cool at the point of entrance to the heater. It was undoubtedly saturated with water vapor. The temperature of the air being known, the partial pressure of the vapor may be determined from the steam tables. Subtracting this from the total pressure of the mixture secures the partial pressure of the air. The volume of the air may then be computed by applying Boyle's Law, and in accordance with Dalton's Law the vapor must occupy the same volume. The specific volume of the vapor, obtained from the steam tables, divided into the total volume gives the weight of moisture per pound of air. A similar process will determine the amount of moisture in the exhaust air, the temperature of which was that of the condensate and the pressure that of the atmosphere. The data and results of the air and steam mixture tests are presented graphically by the various curves of Figs. 5, 6, 7 and 8.

Discussion of Results

All curves illustrating the results of the air and steam mixture tests are in accordance with the stated observations of other experimenters regarding the gain in economy by the use of air and steam together. The curves show that the maximum economy occurs with mixtures containing about 30 per cent of steam. The maximum gain is more pronounced when cold air, rather than air previously heated, is used. This gain becomes still greater as the load decreases. The gain at the maximum load carried with air at an initial temperature of 410 deg. F. is 5 per cent, while the gain at approximately the same load with cold air at a temperature of 100 deg. F. is about 15 per cent. At three-quarters of the maximum load and with air supplied at a temperature of 100 deg. F. the gain is about 24 per cent. Tests at less than three-quarters of the maximum load carried were impractical because the pressures after expansion were below the back pressures on the engine, as indicated by a loop in the toe of the indicator diagram.

Results obtained by Reynolds in his experiments furnish a partial explanation of this phenomenal gain from using a mixture of air and steam expansively. In steam engine operation, initial cylinder condensation is chiefly responsible for the great difference between the actual and the theoretical steam consumption. Any method which reduces the loss from such condensation will therefore improve the efficiency of operation. Since the total pressure of a mixture of air and steam is the sum of the partial pressures of the two constituents,





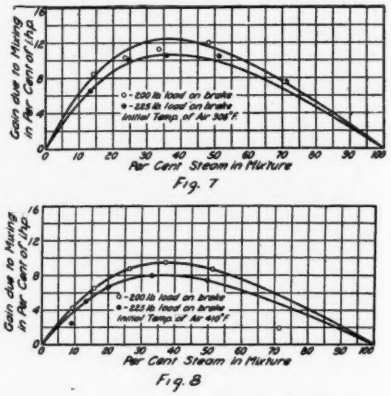


FIG. 5. PERCENTAGE GAIN IN I.HP. FOR DIFFERENT PERCENTAGES OF STEAM IN MIXTURE; INITIAL AIR TEMPERATURE 100 DEG. F. FIG. 6. PERCENTAGE GAIN IN I.HP. FOR DIFFERENT PERCENTAGES OF STEAM IN MIXTURE; INITIAL AIR TEMPERATURE 203 DEG. F. FIG. 7. PERCENTAGE GAIN IN I.HP. FOR DIFFERENT PERCENTAGES OF STEAM IN MIXTURE; INITIAL AIR TEMPERATURE 306 DEG. F. FIG. 8. PERCENTAGE GAIN IN I.HP. FOR DIFFERENT PERCENTAGES OF STEAM IN MIXTURE; INITIAL AIR TEMPERATURE 410 DEG. F.

the steam may be in a superheated condition in such a mixture. When such a condition exists, the initial cylinder condensation is reduced, with a consequent increase in efficiency. A further explanation of the improvement in efficiency may be found in Rankine's statement that the air has a tendency to increase the working temperature limits of the steam, independently of the addition of heat. It may be noted, furthermore, that the presence of air reduces the effectiveness of the interchange of heat between the working fluid and the metal walls of the cylinder, thus causing a reduction in the heat loss.

Description of Experimental Plant

In Fig. 9 is shown a diagrammatic arrangement of the equipment used in the foregoing tests. The air-compressor is not shown in either figure, but its use is explained and its relative position indicated in the following description of the plant. To reduce the pulsations of pressure from the compressor, the air was delivered to the first receiver shown in Fig. 9. From the first receiver the air passed through the Venturi tube to a second receiver employed to reduce the pulsations of pressure produced in the air pipe by the engine. Between the second receiver and the engine, the air passed through several feet of pipe which could be heated externally by gas burners. When the air was heated to the desired temperature, it was delivered into a mixing chamber located immediately above the engine throttle valve. High pressure steam could also be admitted to this mixing chamber, as shown in the figure. By this arrangement, it was possible to secure the desired proportion of steam and air for the mixture tests.

The engine was built by the Murray Iron Works Co., of Burlington, Iowa. The builders' rating for steam when operating non-condensing with 100 lb. gage pressure, 100 r.p.m., and cutoff at one-quarter stroke, is 24 indicated horsepower. The governor is of the weighted flyball type.

Accessories of the engine used in all tests consisted of a Prony brake, condenser, weighing tank, revolution counter, reducing motion, mixing chamber, calorimeter, and two Buffalo scales, one used with the brake and the other for weighing the condensate. The condenser was of the Dean surface type having 100 sq. ft. of condensing surface. There was no vacuum pump attached. A thermometer cup was inserted at the outlet of the condenser for taking the temperature of the condensate and air. The reducing motion was of the "rod and groove" type with grooved and notched discs for engaging the indicator cord. The discs were 2¾ in. in diameter, and the diagrams produced were approximately 4 in. long. An adjustable force-feed lubricator furnished oil to the cylinder and valves.

Between the compressor and the meter is a receiver with a capacity of 65 cu. ft. It was fitted with a blow-off valve which was adjusted by means of a sliding weight. The second receiver, which had a capacity of 17 cu. ft. was located between the meter and the engine. The meter was thereby freed from the disturbing effect of the reciprocations of both engine and compressor, so that there was no appreciable oscillation of the liquid in the manometer.

A portion of the 2-in. pipe leading from the second receiver to the engine was fitted with a jacket composed of 12 ft. of 3-in. pipe sealed with an ammonia fitting at each end. Both cold water and steam were piped to the jacket, and by this arrangement it was possible to regulate the temperature of the air within the lower range, the highest temperature thus attained being slightly greater than 200 deg. F. For higher temperatures, a battery of four blow-torches was arranged to play on a vertical section of the pipe which was surrounded by approximately 4 ft. of stove pipe covered with asbestos lagging. With both heaters utilized simultaneously, a temperature of 400 deg. was readily obtained for the maximum amount of air used in the air tests.

Located immediately above the engine is the mixing chamber. This consists of 4½ ft. of 6-in. pipe covered with magnesia lagging. A 4-in. perforated pipe closed at the end projected up into this mixer and caused any condensed steam present to be separated and held at the bottom of the chamber until drawn off at the end of the test.

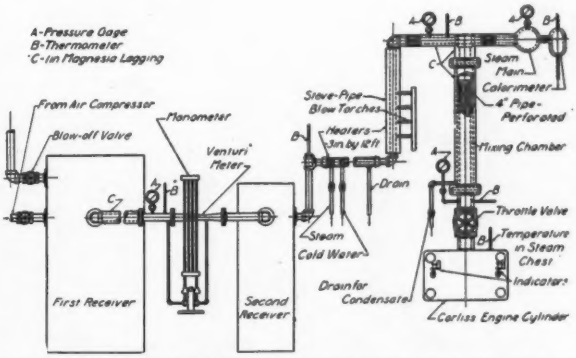


FIG. 9. DIAGRAMMATIC ARRANGEMENT OF APPARATUS

Regulation of the steam pressure was effected by means of a throttle valve located in the steam main several feet from the engine and compressor. To make it possible for the operator of the valve to be near the engine, a rope and pulley arrangement was used. The flow of air was regulated by a throttle valve placed between the first receiver and the Venturi meter.

Federal specifications and testing methods covering various petroleum products are given in Technical Paper 323, just issued by the United States Bureau of Mines. The specifications cover motor gasoline, aviation gasoline, naphtha, kerosene, lighthouse kerosene, signal oil, fuel oils, fuel oil for Diesel engines, bunker fuel oil, and lubricants. Under the general heading of lubricants, special specifications are given for aircraft machine gun oil, car and locomotive oil, cup grease, Diesel engine lubricating oil, floor oil, gun and ice-making oil, paraffin wax, electric switch oil, rust-preventing compounds, etc.

Specifications given were recommended by the Interdepartmental Petroleum Specifications Committee, of which N. A. C. Smith, petroleum chemist of the Bureau of Mines, is chairman, and have been officially adopted by the Federal Specifications Board for the use of the departments and independent establishments of the Government in the purchase of materials covered by them. The Interdepartmental Petroleum Specifications Committee was assisted in the preparation of the specifications by an advisory board consisting of representatives of several engineer and technical societies.

Figuring Diesel Plant Costs

FIXED CHARGES AND OPERATING COSTS SHOULD BE SEPARATED. BY P. M. THAYER*

THERE are a great many different items entering into the cost of operating any power plant. The relative value of many of these items can be radically changed by the choosing of proper equipment for the particular conditions of load that the plant will operate under; so the success of an installation depends on the correct analysis of the conditions which the plant will have to contend with and the correct application of machinery to meet those conditions. It is the purpose of this article to discuss the various items which enter into the cost of operating a Diesel engine plant, rather than to enter into a discussion of the pros and cons of whether a Diesel engine plant would be applicable to any given conditions.

When any new project is discussed by a Board of Directors the first question asked is, "Will it Pay?" so that this question must be answered satisfactorily before any serious consideration is given it. These same directors will want to know what the cost of installation will be and how much it will cost to operate so they can determine the advisability of going ahead with this particular improvement. These same questions come up regardless of whether the plant is to be a central station, an industrial plant, or a municipal plant. Therefore, it is of prime importance to know what items there are that enter into the cost of operating a Diesel plant and on what basis these costs may be figured.

All the items entering into the cost of operating a power plant can be classified under two general headings: Capital Charges or Fixed Charges, as they are more often called, and Operating Costs. It often happens in a Diesel plant that the fixed charges exceed the operating charges, so that in deciding upon the type and size units to install a very careful study must be made in order to get the lowest overall cost. That is, to get a plant which will have the lowest total cost per kilowatt hour taking into consideration both fixed charges and operating costs.

Fixed charges are costs chargeable to capital investment and include interest on the investment, taxes, insurance, and depreciation. All these fixed charges are figured as a percentage on the total investment, which includes not only the cash outlay for the machinery and real estate, but also all labor and material required to install this equipment ready to operate. Machinery is usually sold f.o.b. works, so that the freight to destination is a part of the cost of the plant, although it is an

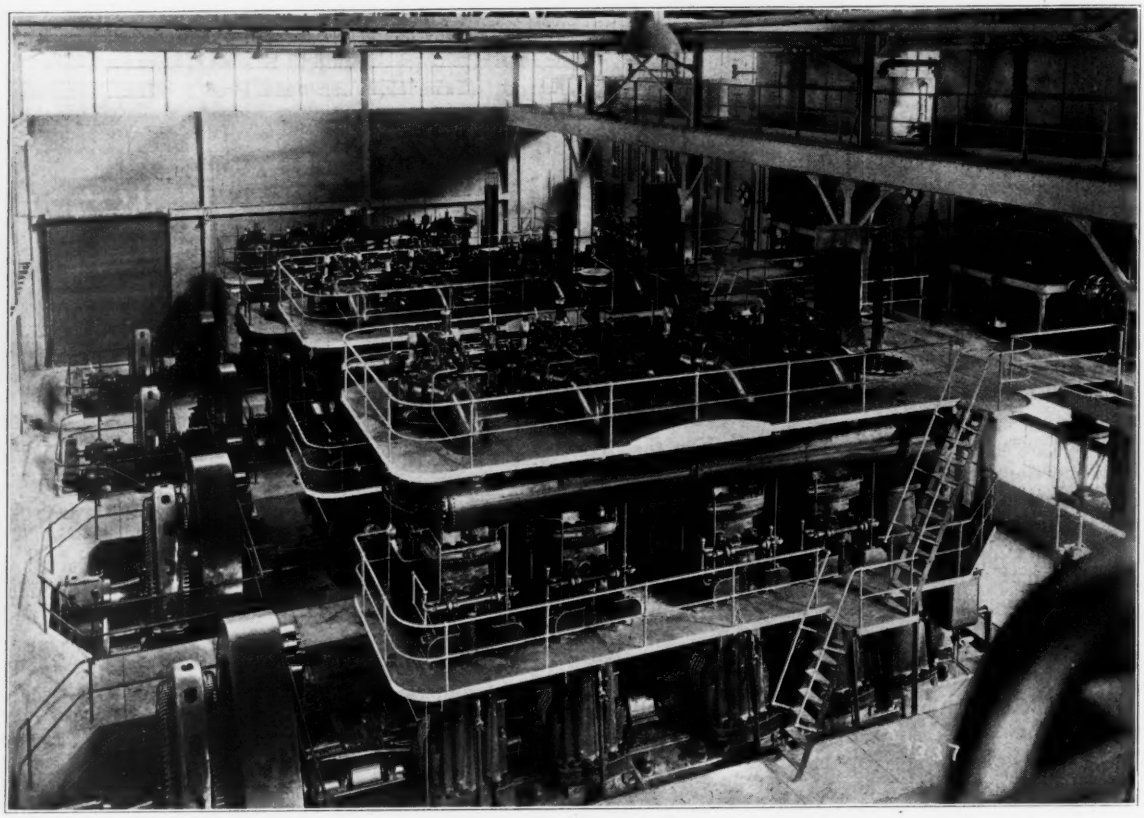


FIG. 1. DIESEL PLANT OF COPPER QUEEN MINING CO., BISBEE, ARIZONA

In this plant there are two 2000-b.hp. Diesel engines direct connected to 1500-kv.a., 120-r.p.m. generators and two 1250-b.hp. engines direct connected to 815-kv.a., 180-r.p.m. generators. Engines are of the Nordberg Carels type.

*Sales engineer, Nordberg Manufacturing Co.

intangible asset. The machinery arrives at its destination on board freight cars in a great many pieces; these pieces must be transported to the engine foundations and there built up into a complete power generating unit. This work requires labor and material which do not appear in the final plant at all, but which are items of cost just as much as the building or the machinery in it. To sum the whole matter up it is necessary to take as the cost of the plant all the money which is spent for real estate, buildings, foundation, engines, generators, exciters, switchboard and wiring, freight, erecting engineer, skilled and common labor, hauling, blocking, piping, fuel oil storage auxiliaries, water supply, mufflers, piping, etc.

Interest, taxes and insurance are always figured on the total investment; sometimes depreciation is charged off at the same rate for the whole investment; in other cases different rates are used for the parts of the plant. Ordinarily a 20 yr. life is assumed for the Diesel plant and depreciation is accordingly written off at 5 per cent per yr. In some cases buildings are depreciated at a different rate than the equipment and this amount depends entirely on the type of building. Theoretically, depreciation should be charged off separately on each item in the plant, but this is splitting hairs and since the life of each item is assumed in the first place, there is no way to tell what the depreciation really should be. For all practical purposes engineers usually use a figure of 15 per cent of the total investment, not including real estate, as being amply sufficient to cover all fixed charges. Incidentally this is also the figure that is used for steam plants as well.

One other chief division of costs comes under the head of operating costs. Under this heading appears such items as labor, fuel oil, lubricating oil, waste, supplies, and repairs. In this category all the items vary with the load except labor. Many times the proper choice of units, both as to size and type, will have a great bearing on all these items of cost. A 2000 b.hp. Diesel engine does not require any more labor to operate it than does one of 200 b.hp., although it is a very short-sighted policy to try to save money at the expense of an adequate operating crew. The service that is required of a plant also has a great influence on the choice of equipment, both as to number and size, as well as to type. When continuity of service is required, as in central stations, it is absolutely necessary to have a spare unit, while in most industrial plants a spare unit is never considered.

Frequently misapprehension exists among those not familiar with Diesel engines as to the type of men and the training necessary to make successful Diesel engine operators. It is the writer's opinion that any man who has the mental aptitude and ability to make a successful steam engine operator, would also make a successful Diesel engine operator. To be really successful in any line, a man must be interested in his work and want to learn about it. To operate a Diesel plant successfully the operator must look ahead and do his maintenance work before it is really required; this merely requires systematic inspection. Men who have the interest of their employers at heart and who take pride in the successful performance of the plant in their charge, are entitled to receive a just remuneration. As already stated, it is poor policy to try to make a saving in operating costs at the expense of the operating crew; any such saving will probably be lost many times over by a greatly increased repair bill. This item of labor is like the fixed charges already referred to—it goes on at full rate regardless of how much or how little the plant runs. It is the only item of operating costs that does not fluctuate to some extent with the power output.

Consumption of fuel oil depends entirely on the power output and the load on the engine. Practically all Diesel engine manufacturers make the same economy guarantees and they are on a conservative basis. There are many grades of fuel oil and the range in price is large. Since practically all grades contain about the same number of B.t.u. per pound, it is apparent that it is desirable to burn the cheapest grade of oil on the market. Unfortunately some of the cheapest grades contain some elements that are detrimental to certain types of engines. Sulphur is the most troublesome constituent with which to contend as it forms sulphuric acid in the

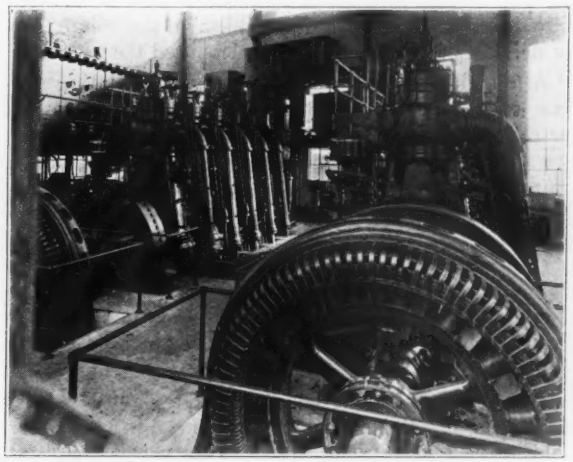


FIG. 2. MUNICIPAL PLANT, MARSHALL, MICHIGAN, WITH TWO 550-B.HP. NORDBERG ENGINES CONNECTED TO 500-KV.A., 225-R.P.M. GENERATORS

exhaust gases and may cause serious trouble to the exhaust valves of a four-cycle engine; a two-cycle engine is free from this difficulty.

In the average power plant operating under a widely fluctuating load it will be found that the fuel consumption will be in the neighborhood of 10 kw.-hr. to the gallon of fuel oil. This is the result that can be expected under such a load as is found in the average city power plant supplying both power and light on a 24-hr. schedule. Under more favorable conditions this might be increased to 11 or even 11½ kw.-hr. per gal. Ordinarily the cost of fuel oil in a Diesel plant is not of such prime importance because it is relatively a rather small amount when compared to the fixed charges. Hence it is not usually good practice to pick engine sizes solely with the idea of operating at the most economical point, as it usually happens that the first cost runs way up when this is done.

Practically all Diesel engines are fitted with a continuous system of lubrication. Some builders use a gravity system, while others force the oil under pressure to the various pins and bearings. In either case the oil is collected in the crank pit and is filtered, cooled, and circulated over and over again. In this

manner the lubricating oil consumption is kept very low as there is practically no way to lose this oil except by leaky pipe connections or by vaporization. The cylinders are always supplied by a different system entirely. Force feed pumps are used on all engines and great care is taken to prevent the oil which comes in contact with the hot cylinder walls and pistons from running down into the crank pits and mingling with the oil in the continuous oiling system. The same oil is ordinarily used in both systems, but the oil that comes in contact with the highly heated surfaces of the cylinder walls and pistons becomes fouled and is discarded after being used once. In this particular, Diesel engine practice closely follows steam engine practice.

Of late years the use of water cooled pistons has received much attention from the leading builders. Where these have been used the difficulties in lubricating the cylinders have largely disappeared. The air compressor is always on still another lubricating system; it is lubricated by means of a force feed pump and is supplied with a special air compressor oil. The air compressor requires very little oil, in fact the less used the better.

Although there are three different lubricating systems on a Diesel engine, the total amount of oil used per day is small. A 500-b.hp. engine will require from 2 to 2½ gal. of lubricating oil per 24 hr. although there are numerous records of engines of this size using only 1½ gal. per 24 hr. One leading manufacturer gives the lubricating oil requirement as being 0.001 lb. of lubricating oil per brake horsepower-hour for large engines and 0.0015 lb. for small engines. As in the case of labor, it does not pay to cut corners on lubricating oil, either by buying an inferior quality or by trying to reduce the amount used to too great an extent.

Use of waste used around a Diesel plant is a very small item, but it is of sufficient importance to warrant being carried as a separate item on the power plant cost sheet. The amount required for a Diesel plant is just about the same as would be required by a steam plant of equal size.

There are always a lot of miscellaneous items that are hard to classify such as electric light bulbs, tools of various kinds, pipe fittings, etc. These various items that are essential to the proper operation of the plant should all be set down under some heading on the cost sheet. Since there is no outstanding item among them they are all grouped together as supplies. In a year's time this item will amount to about one-half of the waste used.

There is a great deal of misinformation about the cost of maintaining a Diesel engine. Perhaps a brief statement as to the mechanical features of some of the later designs will show how many of the troublesome features of the early engines have been improved or eliminated altogether. The parts of the engine which come into direct contact with the hot gases during burning and exhaust are naturally the parts that give trouble. These parts which require special attention are cylinder head, cylinder liner, piston, piston rings, and exhaust valves. The cylinder heads on all engines are water cooled and are made as simple as possible. A cylinder head should last the equivalent of 2 yr. of continuous operation, provided the engine is not overloaded. Almost all Diesel engines nowadays are made with cylinder liners; ordinarily a cylinder liner should last from 2 to 3 yr. continuous service. The life of the piston depends largely on the type and size. Water cooling the piston insures much better lubrication and prevents the formation of carbon. Piston rings usually last from 1 to 2 yr., depending largely on how well the cylinders are lubricated. Exhaust valves are the cause of some trouble, especially with heavy oils when sulphur is present. The inlet valves never cause trouble. The exhaust valves have to be reground every 2 to 3 mo. and usually last about 2 yr. The fuel valve has to be looked after closely, but since it does not come in direct contact with the heat its maintenance is slight.

Outside of the items mentioned above there is practically no difference between the running parts of a Diesel engine and a steam engine. The high pressure air compressor must be kept in good condition at all times. This means grinding valves, with occasional replacement, new piston rings and keeping all air connections tight. The parts are all small so that the expense for new parts is small. The answer to the question of how to make a reliable air compressor for Diesel engines lies primarily in the proper cooling of the compressor itself and thorough cooling of the air between stages. As made by the leading manufacturers, the high

COST OF OPERATION, JANUARY, 1922, FOR A PLANT MADE UP OF ONE 500-KW. DIESEL ENGINE AND THREE STEAM ENGINES TOTALING 600 KW.

Hours run	685.5
Total kw.-hr. generated	213,580
Percentage time run	92.
Load factor, per cent	69.
Interrupted service	none
Fuel oil consumed, lb.	155,314
Lubricating oil consumed, gal.	200
Cylinder oil consumed, gal.	43.5
Waste, lb.	50
Rags, lb.	20
Fuel oil in storage tanks, per gal.	$ .03
Lubricating oil, per gal.	.64
Cylinder oil, per gal.	.73

Cost Sheet

Labor charge	$ 474.60
Interest on investment	375.00
Waste and rags, 16.5c and 15c per lb.	11.25
Fuel oil	621.25
Lubricating oil	128.00
Cylinder oil	31.75
Total operating cost	$1641.85

Cost per kw. hr.

Fuel oil	$0.002,840
Lubricating oil	0.000,585
Cylinder oil	0.000,143
Labor	0.002,170
Waste and rags	0.000,056
Interest on investment	0.001,890
Total operating cost	$0.007,684
Diesel engine down, hr.	58.5
Steam engine on when Diesel down, hr.	61.
Steam engine on peaks, hr.	16.
Steam engine total for month, hr.	77.
Kw.-hr. generated by steam, estimated	20,000

pressure compressor is a very reliable piece of apparatus. The various other parts of a Diesel engine, such as fuel pumps, governor, etc., are relatively small, requiring practically no replacement to speak of, but they do require inspection and cleaning.

One large mining corporation which operates over 30,000 b.hp. of Diesel engines in the Southwest has made a very exhaustive analysis of Diesel engine operation covering the last 8 yr. They find that a Diesel engine reaches its level of repairs by the end of the second year. They also report that the annual repairs amount to about $2 per kw. yr. Taking all the figures and facts available, it seems to be conclusively proved that the repair cost of a Diesel plant will certainly be no higher than the repair costs of a steam plant of equal capacity.

In some cases the lighting and heating of the engine room are figured in as separate items, but this all depends on the individual installation. One other item must be mentioned and that is the cooling water. A Diesel engine requires from 6 to 8 gal. of cooling water per b.hp. hr. The discharge head on the pump should be equivalent to about 20 to 30 lb. at the engine room floor line. At this pressure, the cost of pumping water amounts to about 1c per 1000 gal. pumped.

In the foregoing the various items are given that must be taken into account in figuring the cost of operating a Diesel engine plant, together with some facts and figures whereby the probable amounts can be arrived at. To illustrate how a cost sheet can be made up, the actual cost sheet of a 500-kw. Diesel unit is given. In this particular instance the item of depreciation has been omitted.

Engine Safety Improved by Closed Circuit Stop

NUMEROUS steam engine installations exist where it is advisable, for safety and operating reasons, to install some form of a quick closing control valve.

Remote control of these valves, from one or more stations, may be accomplished either manually or electrically. Either method has several advantages; however, it is probably advisable to use the electrical method where there are a large number of stop stations with some of them located relatively long distances from the control valve. The electrical systems may be classified as open and closed circuits; the latter is preferable from the safety viewpoint because any serious defect that might develop will immediately make itself evident by shutting down the engine.

In Fig. 1 is shown a closed circuit diagram that has proved practicable. This diagram makes use of an open circuit annunciator, which would be an advantage should it be desired to cut over an existing open circuit system. The operation is as follows:: Current from battery C flows through lead 1 to magnet B, then through lead 2, thus forming a closed circuit and holding contact K open. Leads 3, 4 and 5 are normally open. When any button is pushed, the current flow to the magnet is interrupted, allowing the spring to close contact K and complete the circuit to the engine stop coil. At the same time, the circuit is closed through the annunciator, causing it to register. The advantages of an annunciator may be questioned; however, it will often prove of value as a safety element for quickly locating trouble and ascertaining the necessity for an engine shutdown.

In Fig. 2 is shown the type of push button required. The two upper contacts are normally on the closed circuit. The upper contact on the battery side is connected

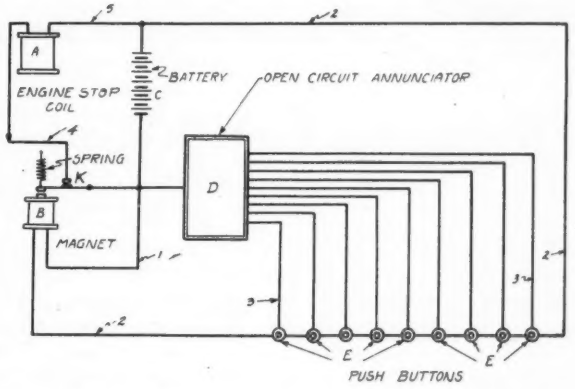


FIG. 1. WIRING DIAGRAM FOR CLOSED CIRCUIT ENGINE STOP

direct to one lower contact, while the other lower contact is connected to the annunciator.

It is best to have the battery and magnet located near the engine stop. Any break between the battery, magnet or any push button will immediately cause the control valve to close. A break between any push button and the annunciator will not interfere with the effective operation of the engine stop coil.

Push button stop stations should be located where they will be easily accessible, and reasonably safe from

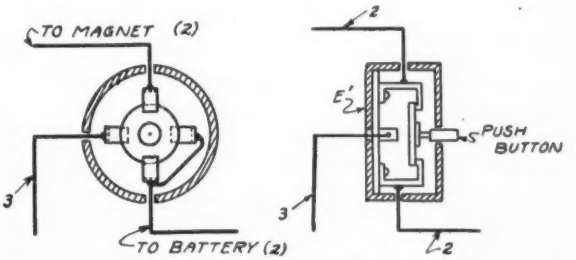
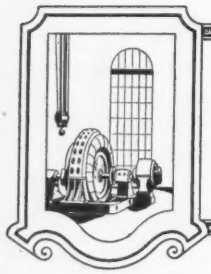


FIG. 2. DIAGRAMMATIC SKETCH OF FOUR CONTACT PUSH BUTTON

accident. Sign markers, or better still, a marker and a colored electric lamp, should show the location of each stop station. Push buttons will be found preferable to switches for the reason that they return to their normal position, due to the spring action.

INFORMATION has been asked by some readers in regard to the Van Stoning of wrought iron pipe. We are informed that the Pittsburgh Piping & Equipment Co. have perfected a method by which they are successfully Van Stoning wrought iron pipe for Van Stone joints up to and including 8 in., and that they expect soon to be able to go as high as 16 or 18 in.

YOU'LL NEVER get ahead if you're satisfied merely to get by.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Operating Features of Generating Equipment---II

DIFFICULTIES OF REGULATION ENCOUNTERED WITH SHUNT MACHINES OVERCOME BY USE OF COMPOUND WOUND UNITS. BY V. E. JOHNSON

TO OVERCOME the difficulties encountered in regulation of shunt wound machines because of the drooping characteristic, manufacturers began, quite early in the game, to add to the fields an auxiliary winding which was connected in series with the load. This compound winding which is shown diagrammatically in Fig. 1 is placed on the same poles as the shunt field windings previously described.

The series winding consists of a few turns of heavy wire, so connected that the flow of the load current

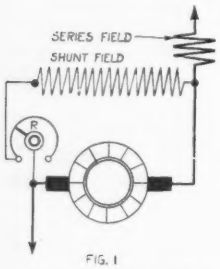


FIG. 1

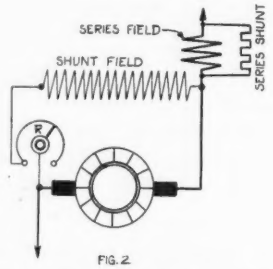


FIG. 2

FIG. 1. DIAGRAM OF A COMPOUND WOUND MACHINE. THE SERIES WINDING IS PLACED ON THE SAME POLES WITH THE SHUNT WINDING

FIG. 2. DIAGRAM OF COMPOUND MACHINE PROVIDED WITH A SERIES SHUNT

causes the field flux to become stronger and thus overcome the objectionable drop in the straight shunt machine. Obviously the amount of compound field magnetism varies with the load current flowing, so that the amount of compensation is automatically adjusted to meet load requirements.

If the compound winding on a given generator is too powerful for the load conditions under which it operates, the voltage will rise too high. To remedy this, a portion of the load current is diverted or "bypassed" around the series field, by means of a shunt connected as shown in Fig. 2. By properly proportioning this, any desired amount of current can be diverted, so that virtually any amount of "compounding" can be obtained. The adjustment, however, is not very easy to make, as it consists either of shortening or lengthening the shunt or of the introduction of washers in the connections. The setting is then left undisturbed until some variation in the operating conditions requires a readjustment.

In compound wound, non-interpole machines, it is possible to adjust the compounding by shifting the brushes forward or backwards in the commutating zone, as described in the March 1 issue under "Shunt Machines."

PARALLEL OPERATION OF COMPOUND MACHINES

PARALLEL OPERATION of compound wound machines is not quite as simple as that of shunt wound machines.

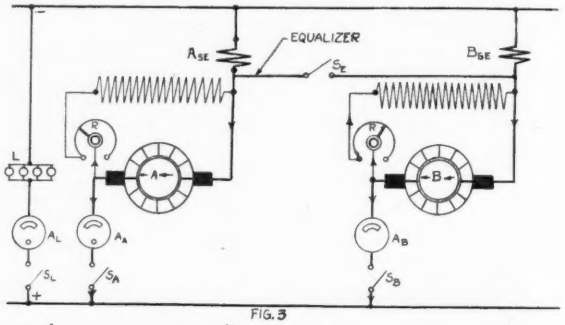


FIG. 3

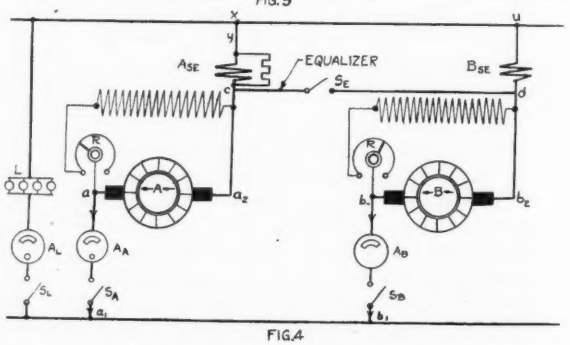


FIG. 4

FIG. 3. TWO COMPOUND GENERATORS ARRANGED FOR PARALLEL OPERATION SHOWING METHOD OF CONNECTING THE EQUALIZER

FIG. 4. TWO COMPOUND GENERATORS IN PARALLEL WITH A SERIES SHUNT ON ONE MACHINE

In Fig. 3 is shown a diagram outlining two compound wound generators arranged for parallel operation. The outstanding feature in this scheme of connection is the use of the "equalizer." To make the function of the equalizer clear, consider A and B as having been connected in parallel, as were the shunt machines previously discussed. The equalizer connection is left open by leaving the equalizer switch SE open. The current flowing through the series fields ASE and BSE, as indicated, is in the boosting direction and their flux is added

to the flux of the shunt fields. As long as the external voltages of A and B are equal the ammeters AA and AB will indicate the same value of current. Suppose, now, that the voltage of A becomes slightly higher than that of B, due to, say, a speeding up of the prime mover on A, or to an increase in B's field resistance from heating. Immediately the balance is upset. A, having a higher voltage, passes more current into the line than does B; its series field becomes stronger, increasing the voltage still more. On the other hand, B's series field carries less current and its voltage becomes successively lower. The net result is that A finally takes all of the load and B none—in fact, B may even run as a motor. Unless the armature reactions of the two machines are sufficient to prevent it, the final result is that the series field of B overcomes the shunt field and so reverses the polarity. The condition then becomes analogous to that in Fig. 4, March 1 issue, with the added hazard due to the series fields increasing the current flow to extreme and generally destructive values.

Consider now the effect of closing the switch SE before the switches SA and SB are closed. It will be noted that this puts the series fields of the two generators in parallel, independently of the armatures. If, now, the machine voltages be made the same, and the main switches closed, the condition incident upon a small increase, say, in A's voltage, is as follows:

A generates more current, but this current passes partly through the series field of B and so adds to B's voltage. It follows that any unbalance in loads is largely compensated for—with the net result that instead of having a condition of unstable equilibrium as in the previous cases, we now have an operative condition.

On large machines it is customary to have a separate switch on the equalizer circuit. This is often located on a pedestal between the machines, or is mounted on the frame of the generator. This arrangement saves running the heavy equalizer leads to the switchboard. On smaller machines the main switches are made 3 pole—the middle blade serving as the equalizer switch. This is an advantage from the operating standpoint, as it makes it impossible for the machines to be connected in parallel without closing the equalizer.

While the use of the connection shown in Fig. 11 makes possible the stable operation of compound wound generation in parallel, it does not of itself produce a satisfactory division of loads. This, as in the case of the shunt wound machines, is dependent upon the relation between the load characteristics. These characteristics may be adjusted—as previously explained—in non-interpole machines by adjusting the brush position, and in either type by using a shunt to divert a portion of the load current from the series field. The latter method can, however, not be used for securing satisfactory load division between compound wound generators.

Securing Load Division

In Fig. 4 are shown two compound machines connected in parallel and a shunt around one of the series fields. A little consideration will clearly show that this shunt is really across both series fields and will therefore reduce the compounding on both machines.

It is evident, then, that to reduce the series current of either machine it will be necessary to increase the resistance of the connecting leads. Thus, A's characteristics can be flattened out by a shunt, as shown; but when B is connected, it too will have a flatter curve and the load relations will remain virtually unchanged. On the other hand, by increasing the resistance of the lead XY, less current will flow through ASE and more through the shunt and BSE.

This is the practical way of securing load division and is done by lengthening or shortening the connecting cables. For machines of the same size and design, the resistance of a-a_1 should equal b-b_1, a_2-x should equal b_2-u and a_2-c equal b_2-d. If the machines are of unequal size, then the cables connecting the generators to the busses should have resistances inversely proportional to their capacities. Or, stated differently, with machines carrying their proper share of the total load, the drop in the connecting cables should be the same for both (or all) machines.

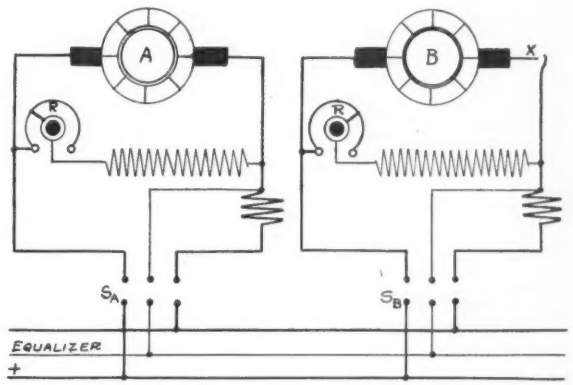


FIG. 5. DIAGRAM ILLUSTRATING METHOD OF CORRECTING POLARITY

For example—if A is twice the size of B—then each part of A's connecting cables should have ½ of the resistance of the corresponding parts of B's conductors.

Correcting Polarity

On direct current machines, it occasionally happens that improper switching conditions or external causes produce a reversal of polarity; in other words, the residual magnetism has become reversed so that it is impossible to parallel the machines. The simplest way to correct this is shown in Fig. 5, where the switches are drawn in the position which they usually occupy, instead of in the schematic positions in the previous diagram. If the voltmeter indicates that B has become reversed, shut it down, disconnect one of the main leads from the armature as at X, and close the switch SB. Current from A will flow through the shunt field of B and correct its polarity. The same result can be accomplished by raising all of B's brushes. In either case, the armature circuit of B is open so that it does not act as a short circuit across A.

Commutation

Earlier in this article, mention has been made of "armature reaction" and of its effect on the load characteristics of the generator. More important than the drop of voltage which it produces is its effect on commutation.

Commutation is a broad subject and cannot be discussed here except in the most elementary manner. Every engineer, however, sooner or later experiences

commutation troubles, so the subject cannot be entirely overlooked.

Brushes must, of course, be wider than one commutator bar; if they were not, the current would be broken every time a bar passed from underneath the brush. On the other hand, if brushes are wider than one bar they must, when passing from segment to segment, necessarily short-circuit one or more armature coils. This, then, is one of the inherent difficulties which must be overcome.

An armature carrying no current becomes merely a part of the magnetic circuit of the generator, and the

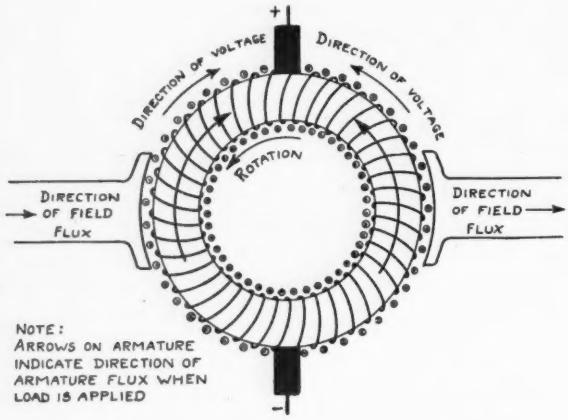


FIG. 6. SIMPLE ARMATURE CIRCUIT SHOWING DIRECTION OF FIELD FLUX

conductor on its surface in no way affects the distribution of the lines of force. As soon as these conductors carry current, they set up a magnetic field of their own in the armature iron and this magnetic flux mingles with the field flux and produces a resultant field which varies in strength and position with the amount of current flowing. This is another one of the inherent commutation difficulties which must be overcome.

Commercial considerations make it desirable that heating rather than commutation be the limiting factor in rating machines. This makes it imperative that iron and copper be worked at the highest possible point and that operation be sparkless throughout the load range of the machine. Operating conditions require that attendance be reduced to a minimum. These, then, constitute two more inherent problems to be solved.

In a direct current machine, the armature winding consists essentially of one or more completely closed circuits, so that a diagram such as Fig. 6 shows correctly the general connection between coils—regardless of how the coils are laid on the armature—and broadly speaking covers both lap wound and wave wound machines. For the sake of clearness, the brushes are shown as resting directly on the coils, as indicated, although in actual construction the coil connections usually are so arranged that the brushes are about in line with the centers of the main poles. Only the position of the coil which lies on the outside of the ring armature is cut by the flux, the inside half of each lap serving merely as a connecter. With the rotation and flux flow indicated by the arrows, the direction of voltage in the armature is shown by the dots and crosses—where the dot is the point of an ascending arrow and the cross is the tail of a descending arrow. Inasmuch as the conductors on the interior of the ring are ineffective, the result may be shown by Fig. 7, which indicates roughly the direction of the induced voltage and also the direction of the current flow upon closing the circuit.

When the external circuit is closed through a load, the current flowing in the conductors magnetizes the armature iron and produces a flux upward to the top of the page, as indicated by the arrows and flux lines. Thus, in Fig. 6 we have the field flux alone—while in Fig. 7 we have the armature flux alone. In the machine, these combine to form a resultant flux as in Fig. 8.

Consider now the brush position. In Fig. 6 the brushes are set on a diameter at right angles to the axis of the fields, because at this point the armature coils cut no flux and have no voltage generated in them. Stated differently, this is the point where the currents flowing upward through the two halves of the armature meet. In Fig. 8, on account of the distortion due to the armature current, the point of no voltage is no longer at the neutral point N, but at some point as A, determined

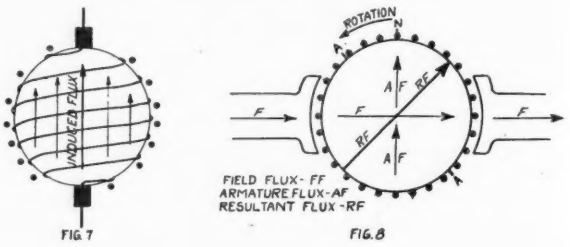


FIG. 7. EQUIVALENT EFFECT OF CONDUCTORS ON RING ARMATURE

FIG. 8. RESULTANT FLUX PRODUCED BY ARMATURE AND FIELD FLUX

by the relative strengths of the field and armature magnetism.

A further consideration of Fig. 8 will show that if the brushes are moved forward to the point A that a number of the armature conductors now carry current in such a way as directly to oppose the field magnetism, their effect being shown roughly by Fig. 9. These are the demagnetizing turns, so called because of their action.

It is evident from the foregoing that under varying load conditions the point A would occupy correspondingly different positions. If the armature flux were relatively weak—even at full load—as compared with the field flux, the amount of movement of the point A would be reduced, but even under the most favorable conditions the limits of commutation would be reached before the heating limit.

Effect of Interpoles

If now auxiliary poles be located as shown in Fig. 10, and these be energized in proportion to the load on the machine by the simple expedient of passing the load current through their windings, a counter flux will be set up, as indicated by the arrows, which will to a large extent overcome the difficulties due to field distortion.

The brushes are left at neutral so that there will be no demagnetizing turns. As a result, the load curve does not drop off as rapidly as in the generators which do not have these auxiliary interpoles, and even under moderate overloads the necessity for shifting the brush position is obviated. The design of the interpoles, both as to electrical and magnetic circuits, must, of course, be such as to bring about saturation in the armature magnetic circuit and on the interpole circuit at the same rate. Machines do not usually leave the factory until the proper adjustment has been made, and on modern generators even the brush position is determined and definitely located by means of dowel pins in the yokes or by means of templates. "Leave well enough alone" is a good motto for the engineer when it comes to attempted adjustment of either interpole strength or of brush position on interpole machines.

An interpole machine—shunt wound—is sometimes unstable when operated in parallel with another similar generator. If the brushes are set slightly "back" of neutral, there is a compounding effect due to a number of armature conductors becoming "magnetizing turns," just as when the brushes were moved forward some of the conductors became "demagnetizing." If this condition exists, it can be remedied by moving the brushes into the proper position. This should, however, in general not be necessary.

FIG. 9

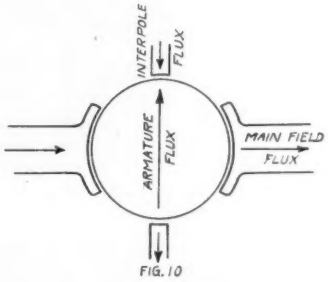


FIG. 10

FIG. 9. EFFECT OF DEMAGNETIZING TURNS WHEN BRUSHES ARE MOVED FORWARD TO POINT A IN FIG. 8

FIG. 10. DIAGRAM SHOWING THE USE OF INTERPOLES AND THE DIRECTION OF FLUX

In Fig. 11 is shown a diagram of two compound wound interpole machines connected in parallel. The connection of the interpoles to the armature leads is determined at the factory, and the proper connection having been made, it is correct for either direction of rotation and whether the machine be running as a motor or a generator. Therefore, one may think of the interpole coil as a portion of the armature circuit itself. The only difficulty which may arise upon reversal of rotation is that brushes which are slightly "leading" now become "trailing" and may bring about the unstable operation previously referred to.

In actual construction, it sometimes happens that due to the few turns on the interpoles, difficulty is experienced in getting them properly proportioned. Thus, one turn more or less may be too great a variation, while it is often mechanically inconvenient to make use of half turns. Under such conditions, the use of interpole shunts is resorted to. These function exactly as the shunts across the series fields, but differ from them structurally. An interpole shunt must be wound around an iron core so as to have an inductive effect corresponding to that in the interpole circuit itself. If this were not the case, under rapidly varying loads the proportion of current between the shunt circuit and the interpole circuit would also vary, and would possibly result in momentary sparking of great severity, or even in a "flash over."

While the interpoles in a great measure overcome the difficulties of distortion, they do not neutralize the armature flux entirely. On large machines, it is sometimes desirable to have still a second auxiliary winding. This is located in the faces of the worn poles and produces a flux so distributed that it, plus the interpole flux, very nearly overcomes the distortion of the field under load.

Even with machines of correct design, however, interpole or non-interpole, as the case may be, sparking sometimes develops. This is usually due to one of the following reasons:

1. The machine may be abnormally loaded, sometimes due to internal grounds, leaks, or short circuits. Or it may be overloaded, due to some external condi-

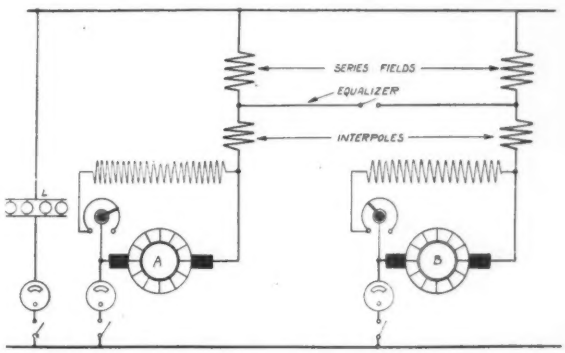


FIG. 11. TWO COMPOUND WOUND INTERPOLE MACHINES CONNECTED IN PARALLEL

tion, accidental or otherwise. The remedy is, of course, to find the trouble and correct it by cleaning the grounds or shorts, or reducing the external load.

2. The interpole circuit may not be carrying its proper current. Sometimes the interpole windings get shorted or grounded, so that only a portion of the compensating current flows through them.

3. The brushes may be displaced, that is, they may either be moved from the proper position with reference to neutral, or they may be improperly spaced.

4. The wrong grade of brush may have been installed. This is an important point, for sometimes an apparently insignificant change in the quality of the brushes produces large difference in operation.

5. The brush tension may be insufficient or unequal. From one to two pounds per brush is about right, the softer brushes taking the lighter pressure. It is well to check this point with a spring balance.

6. The brushes may be "stuck" in the holders, or they may have become so worn that they are too loose in the holders.

7. The brushes may not be making good contact with the commutator, due to improper "sanding in," or to displacement of the brush holders or studs.

8. The commutator may be at fault, having high bars, flat spots, high mica, or being out of round. The remedy for this trouble is to tighten up the studs or collars that clamp the commutator together, and then grinding or turning the commutator.

9. Vibration, due to unbalance or loose bearings, will cause sparking.

10. Dirty commutators, due to excessive use of lubricant or to other external or internal causes, are also a common source of sparking.

There are other causes of sparking; but if the machine comes from the factory with perfect commutation and later gives trouble, the cause is likely to be one of those tabulated above.

Volt-Ampere Meters for Power Measurement*

NECESSITY OF MEASURING KILOVOLT-AMPERES WILL BRING ABOUT THE GENERAL USE OF THE KV.A. METER. BY R. C. FRYER

IT IS WELL known and generally accepted that many things can be done which do not become general practice until the economics governing the practice show that the difference between "cost of doing" and "earnings through doing" is on the proper side of the balance sheet.

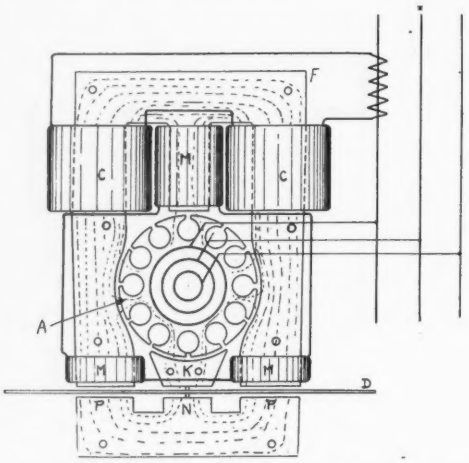


FIG. 1. ONE ELEMENT OF THE ANGUS 3-PHASE METER

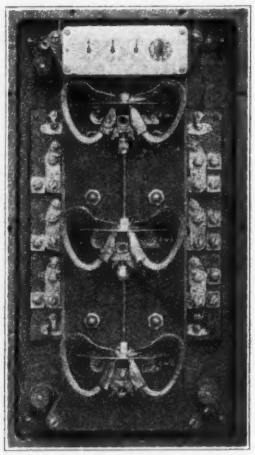


FIG. 2. THREE-ELEMENT VOLTAMPERE-HOUR METER

Being a technician, the engineer may be a little slow to admit, even to himself, this fundamental; yet engineering development, in terms of actual progress for the good of all concerned, is as fully subject to the immutable law based on this fundamental as is human progress in general subject to other economics and psychological laws.

We in the engineering profession perhaps now, more than ever before, are less ready to admit that any task is impossible, yet we will have to admit that in general our research and development follow the cause of the necessity rather than precede it. This in some respects is as it should be, yet the question arises "Would not this necessity be more often clearly recognized and the solution more promptly offered if it were known that means were at hand for meeting the situation or condition brought about by that necessity?"

Recognition of the necessity of metering or measuring kilovolt-amperes of alternating currents first came through experience to manufacturers of electrical machinery. Many who do not consider themselves as aged can remember when it was common to purchase generators, motors, transformers, etc., rated in kilowatts. Due either to the fact that the above-named machines were often required to carry inductive loads or to the fact that under these conditions controversies regarding the capacity ratings of electrical apparatus often arose, the manufacturers took a wise step and changed their a.c. apparatus rating from a kilowatt to a kilovolt-ampere basis.

At the time this took place, the central station industry was carrying a load in which highly inductive apparatus was the exception rather than the rule, and to a large number of central station engineers the full significance of the change was not at once apparent.

During the few years following, which really constituted the "youth" of the central station industry, the effort of the central station was to secure more load, and in the majority of cases very little thought was given to the character of the load with the exception, perhaps, of its load factor. Following these years, however, some of the more progressive central stations carrying industrial loads realized that they were purchasing electrical equipment rated upon a kv.a. basis and apportioning the use of same upon a kw. basis. It became apparent that increased investment was necessary to carry an inductive load over the investment necessary to carry an equivalent non-inductive load. This not having yet become a matter of much importance to many central stations, it did not attract general interest and the result was that where steps were taken to remedy conditions, such action was local in application and generally took the form of penalization of the customer operating an inductive load. Being largely local, the methods and degree of penalization were varied and largely arbitrary. Perhaps we can not be sure, but

*Abstract of a paper presented at the Midwinter Convention of the American Institute of Electrical Engineers.

it seems that, while these attempts were a step in the right direction, the "penalization idea" was not very constructive. Perhaps these attempts secured a better income on the demand charge of customers operating inductive loads, yet no basic attempt was made by manufacturers in general or by central stations to remove the infection, the result being that with each additional industrial load the condition became worse.

About the beginning of the World War, many central stations generated a peak load approaching their kv.a. capacity. Finding it difficult to carry their kilowatt load without exceeding their kv.a. capacity, these stations were faced with the necessity of not being able to care for all load offered or of having to enlarge generating and distributing capacity at a time when the capacity was badly needed and yet at a time when capital for same was very difficult to obtain.

This condition stimulated study of the "low power factor" or inductive load question and it was generally admitted that some action was necessary.

Study of the situation brought out the fact that about 75 to 80 per cent of the central station investment lay in the generating and distributing apparatus. It was pointed out that the carrying capacity of the apparatus covered by this portion of the investment was directly limited by the kilovolt-ampere load. From this it became apparent that while no unit of measurement defined central station capacity in terms of 100 per cent investment, the unit of capacity applying directly to the greater percentage of the investment was and is the kilovolt-ampere.

Many utilities had given a power factor clause trial in their rates, but finding that this complicated their contracts; findings that many customers could not or did not understand its application; finding that most customers did not see the justice of that which they termed "penalization for low power factors;" finding they were unable directly to meter the factors involved and that the human element largely entered into calculation methods and finding that the return given a customer under "power factor correction clauses" was not a direct ratio to his investment in necessary correction apparatus, many utilities allowed the "power factor clause" to become a "dead letter" in the contract.

Results of the attempts cited above are given space in the *T*-2-'22 report of the Subcommittee on Power Factor and kv.a. of the National Electric Light Association Meter Committee, which states that of 418 utilities in cities of 20,000 and over in the United States and Canada, 59 show clauses relating to charges in billing low power factored customers. Among these 59 companies there are more than 20 different clauses.

During the last two years, this condition of affairs has added interest to the development of

(1) Induction motors to operate at better power factors.

(2) Corrective apparatus (static and synchronous condensers).

(3) Kilovolt-ampere meters.

This has led to more study in proportioning the size of the motor to the load carried, and in obtaining both induction and synchronous motors of the proper voltage rating.

Even isolated stations generating and using their own power have found it economical to employ synchronous apparatus.

The writer recently witnessed a 20,000-kw. load in a large rubber mill near Akron, Ohio, operating at 98 per cent power factor. This was secured largely through the unusual practice of using synchronous motors specially designed for operation on rubber mill drive.

It is of course understood that at unity power factor the ordinary induction watt or watt-hour meter will measure volt-amperes or volt-ampere-hours.

It follows that if both the current and voltage fluxes in the meter be held at their proper value and in proper phase relation the meter will measure volt-ampere hours for any power factor, leading or lagging.

Your attention is also called to the fact that if the in-phase and reactive components of a circuit are properly metered the volt-amperes may be known through calculation.

In general, then, any volt ampere meter or volt ampere hour meter must, of necessity, obtain its operation from one or both the above principles.

In classifying the various makes of meters now available under the two types, i. e., proper phase relation

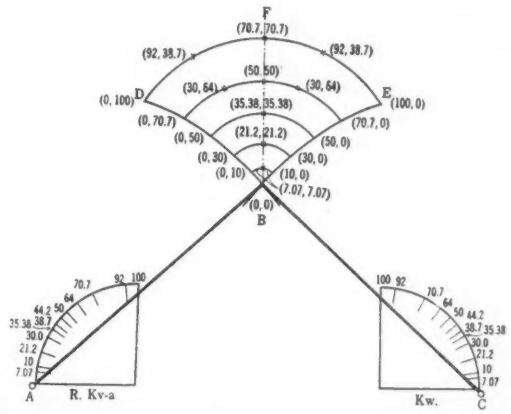


FIG. 3. DIAGRAM SHOWING ACCURACY OF THE KV.A. METER

type meters and the resultant type meters, we have under the former the Bodi meter, the Angus, the General Electric and the Lincoln. Under the resultant type meters we have the full range Lincoln meter, the Sangamo and the Sperti-Blecksmith meter.

The Bodi (Westinghouse) meter involves the principle of operation of the polyphase power-factor meter. It has been found that moving coils carrying the current of the circuit measured (or a portion of same) or carrying the potential of the circuit when suspended in the potential field (in one case), or in the field of the current (in the second case) will take such positions that current taken from them may be in phase with the field in which they are placed.

If then such an arrangement of coils is provided the current from it may be led through the current element of a watt or watt-hour meter and if this current is of the proper value the watt or watt-hour meter is caused to register volt amperes or volt-ampere hours. To supply such a current to the potential element of the meter involves some difficulty since the torque tending to change the position of the movable coils with a slight change in power factor is rather small. More torque for such an arrangement may be had by connecting these movable coils in series and thus supplying current of proper phase relation to the current element

of the standard watt or watt-hour meter. The difficulty encountered with this arrangement, however, is that the volt-ampere load of such an arrangement is rather above the secondary volt-ampere rating of standard current transformers. It must be remembered, however, that with this arrangement the standard induction watt or watt-hour meter may be used.

The Angus meter employs somewhat the same principle with a slightly different arrangement. Instead of using the standard watt or watt-hour meter a special meter comprising in the case of three-phase circuits two elements (one of which is shown in Fig. 1) are used. The frame *F* is magnetized by the current coils *C* and *C*1. The potential element *A* is so mounted that it may rotate, changing its position with variation in power factor of the circuit. The polyphase winding on potential element *A* produces a rotating field about its periphery which reacts against and with the current flux, a portion of which cuts the disk *D* at the points *K N*. This reaction causes the potential element, therefore, to assume a position such that its resultant flux is in phase with the field produced by the coils *C C I*, therefore, the torque on the disk is proportional to volt amperes. With a rotating disk and a register the meter becomes a volt-ampere-hour meter, since the usual type of full-load adjustment can be supplied.

As has been stated, a standard watt or watt-hour meter may be caused to register volt-amperes or volt-ampere-hours if potential of a degree of displacement corresponding to the displacement of the flux due to the current through the meter is supplied. If the degree of displacement of the flux in the current elements of the meter is known, the potential elements of the meter may be wound to cause in their magnetic circuit the same degree of displacement. Under such conditions the meter will measure volt-amperes or volt-ampere hours over about 22 deg. angular range with acceptably good accuracy. The General Electric kv.a. hour meter is of this type.

In Fig. 2 is shown the Lincoln type *V A D* transformer and the Lincoln thermal, volt ampere demand meter. This is a fixed range instrument, but unlike the instrument just previously described the displacement of the potential flux does not take place in the meter itself, but is secured by picking up the desired taps supplied on the small auto transformer provided for the meter. The range of the meter is thereby increased since the change necessary in widely varying power factors can be more readily made, although it must be remembered that the change is to be manually accomplished.

Possibly the latest volt-ampere-demand meter on the market is the Sperti-Blecksmith meter being manufactured by the Westinghouse Co. As shown the meter is designed to register kilowatt-hours and 15-min. block interval volt-ampere-demand. The meter uses standard watt-hour current and potential elements—no special windings being required.

Rotation of the two right disks are proportional to kilowatt-hour and the rotation of the two left disks are proportional to reactive kv.a.-hr. The shafts are connected to two arms operating a pantograph, the center point of which is connected through a flexible lead to the kv.a. demand indicator which indicates the resultant value of the in phase and reactive components—i. e., the square root of the integrated kw. and reactive kv.a. for the interval of time for which the meter may be designed. Further details of operation are shown in Fig. 3.

The reactive meter is so connected to the pantograph that its integrated value is constant in direction for all ranges of power factor, leading or lagging; therefore the standard meter elements are operative over 100 per cent range in power factor. The inherent errors are small, and being constant in progression have easily been cancelled, so that the meter compares in accuracy well with the standard watt-hour meter.

It is seen from the foregoing that quantity production on volt-ampere, volt-ampere-hour or volt-ampere-demand meters merely awaits a consistent demand.

Several large utilities have made, are making and are arranging to make contracts on a volt-ampere demand basis.

It seems safe to assume or predict that during the next few years the volt ampere or "kv.a." meter will have taken its deserved place on a plane equal at least to the present kw. demand meter.

Is Your Job an "I" or a "We" Job?

By Jack L. Ball

MY VOCATION gives me a great deal of pleasure. If it did not, I should choose another. At the same time, it is an incentive for me to visit different plants so that I am able to study different equipment and methods, and further, an excellent opportunity is afforded to study character.

As one of the great army of power plant men in this country, I know that a great many of us suffer from a brain disease called Ego. In many cases, the attack is acute; often it is chronic.

Pride is a mild form of acute Ego and the symptoms are usually made manifest after our successful accomplishment of any task. Many of us like to fit pipe, do wiring or polish brass. After we finish a job, we like to stand back and view our work. Should we speak our thoughts, they might sound like, "There isn't a person in the world that could do that job any better." That's acute Ego and is quite harmless; in fact, it is pride, an engineer's most valuable asset.

The chronic egotists have never been tabulated, but we are certain that a few exist. I ran across one recently in a plant of about 10,000-kw. capacity. With admiration I inspected everything from switchboard to coal storage. The plant was modern, economical, smooth-running and clean. There was a place for everything and everything was in its place. The chief engineer wore a white collar and his trousers were neatly pressed. I looked upon this man as a wonder, a chap highly successful. He hadn't said much during my trip around the plant; but presently, housed up in his little office, he began to talk.

It was "I" this and "I" that. Off guard for a moment, I was almost convinced that this was strictly a one-man plant, or in other words, an "I" job. This chief was a chronic egotist. This was a "we" job, however, and the "we" was the crew upon whom the chief depended. I was a stranger, so this man thought that he would self-advertise his own importance and his job.

Upon one occasion, I visited a large central station where one had to be well known or vouched for to gain admittance. I didn't know a soul at the plant, but I

had a pass. Approaching this particular plant, I had a few misgivings; also, I drew many mental pictures. Finally I entered the engine room, the largest I had ever seen. I looked around with awe and wonder. I had just come of age and had received my first license a short time before. I had really felt that now I was entitled to superior recognition, just the same as many veterans in the power plant field felt at that age and will laugh when they tell you about it.

Well, I had never seen so many engines and direct current generators in my life before. At one end of the engine room two turbines were in operation. Nobody said anything to me, so I walked to a side door and looked down the firing aisle of the big boiler room. Two or three men were giving the stokers constant attention, seriously interested in their jobs. The magnitude of this plant discouraged me. It seemed at that time there were but a few men living that could take charge of a plant of that size. I was firmly convinced that I knew nothing.

I turned to the engine room again and noticed a sign over a door that read "Chief Engineer." I crossed over and timidly entered. I saw a man in overalls sitting at a desk. He was busy with some papers, but presently he turned around, saw me and cordially said:

"Hello! How are you?"

"All right," I answered, after getting over my surprise.

"What can I do for you today?" he then asked.

"Well—I'd like to ask you about a thousand questions about your big plant here," I returned. "It's wonderful!"

"Yes, we do have a nice place here. Now as to your questions: See that tall, grey haired chap over there by No. 7 engine? He'll tell you most anything you'd like to know. Fact is, we all go to him for advice and counsel when we get up against something we can't solve."

I visited that plant many times after that. I learned early the secret of that chief's success: He made the job a "we" job.

I wonder how many of us who are in charge of plants, either large or small, make our plants and our jobs "we" plants and "we" jobs?

Wire Rope Selection and Lubrication

By Geo. F. Swetnam

IN THESE days of high prices and low profits, it behooves us to make every edge cut that will cut, and it is in the hope of making someone's wire rope "cut" a little longer that this article is written.

Care of a wire rope should be begun before it is bought. Selecting wire rope need hardly be so complicated a task as selecting alternators, but it should receive more care than the choosing of alternators sometimes does. There are certain things that should be known about wire rope before buying it, and though some of them may seem to be apparent I shall give them anyway, lest some erring brother might fail to remember one, and so earn himself endless shame:

1. Know what size you want. Too small a rope for the purpose will never last any time, besides the fact that it is a rather dangerous thing to have around. On the other hand, a rope that is too large causes undue overhead, and lasts little longer than one of the right size.

2. Know exactly how much you want. N. B.—Don't fail to make all necessary allowances. It is better to have a little too much than a little too little.

3. Know that it is made by a reputable manufacturer. Don't go guessing and experimenting about this matter. Some manufacturers have a reputation to sustain; others have nothing in view but the largest possible immediate profit.

4. Know that the materials of which the rope is made are good. Look before you buy; if you have the nerve, and know how to judge metal, try the wires with a file to see if they are good. Be sure the core is of good quality.

5. Know that it is well constructed. A little study of well and poorly constructed ropes will amply repay the time spent.

6. And know that it is well lubricated with a good quality of lubricant. Rope that isn't worth lubricating well isn't worth much of anything else; that looks plain enough. Besides this, if the hemp core is not thoroughly saturated with the lubricant it will soon absorb dampness and rot to pieces. This naturally shortens the rope's life very much, and the only way to avoid it when the rope is not lubricated well before manufacture is to immerse the rope in a large metal pot of the lubricant, and bring it to a temperature of about 200 deg. F.

Wire rope should be inspected often enough to avoid all danger of its breaking while in use, and that, together with a little care not to overload, is all the attention it needs except lubrication. The importance of lubrication is emphasized by the little-known fact that in each foot of 1-in. wire rope there is more than 3 sq. ft. of frictional surface. And there is the fact that all this surface requires to be protected from corrosion, while the only agent for accomplishing this is the lubricant.

Of course I have my favorite wire-rope lubricant; but this is an article, not an advertisement, and instead of telling which I think best measures up I shall give my 13 rules for the selection of a lubricant, and let the reader apply them for himself.

1. It must be soft enough to use in all weather.
2. It must cling to the rope tightly enough that it will never break off or spatter off.
3. It must be impervious to any chemicals which are likely to come in contact with it.
4. It must be of such a character as to lubricate the sheave wheels properly.
5. It must be impervious to water in all forms and of all kinds.
6. It is indispensable that it be free from acid.
7. It must not evaporate.
8. No water should enter into its composition.
9. It must penetrate to the core.
10. It must not decompose under any kind of service.
11. It must not harden or crack at low temperatures.
12. It should be capable of being heated to a consistency permitting its application to the particular service on which it is used.
13. It must not wash off.

Such a rope so cared for should give the best possible service.

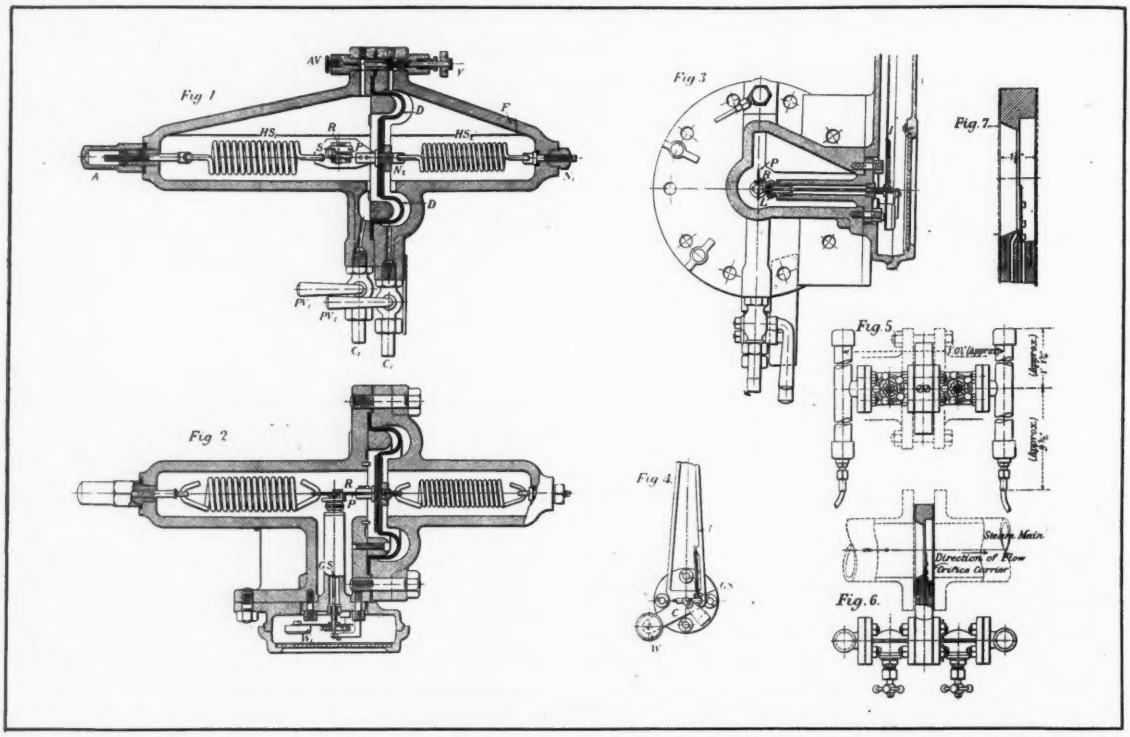
Boiler Load Indicator Uses Rubber Diaphragm

AMONG THE more interesting developments in the power plant field in England is the new boiler load indicator of Messrs. George Kent, Ltd., which was recently described in Engineering of London. This device which is shown in the accompanying illustrations represents a new type of steam meter and was designed especially for boiler house service by John Hodgson, of the above mentioned firm.

Figures 1 to 3 are horizontal and vertical sections through the instrument which is a cylindrical casting, about 20 in. long, mounted in front of the boiler. The dial which marks the pounds of steam consumed is not shown except in section in Fig. 3.

right, the pressure on the up-stream side of the orifice acting on the left hand side of the diaphragm. An increase of pressure will thus cause the slotted plate P which is fixed to the diaphragm to move from left to right. The actual range of the motion is very small; it amounts to 0.3 in. only for the change of pressure corresponding to the maximum flow.

It will be understood that the actuating fluid is not steam, but condensed water; the cooling chambers are added for this purpose to the orifice, and the pipes and the instrument itself are filled with condensed steam. A vertical flat on the plate P pushes up against the roller R seen in Figs. 1, 2 and 3; the roller is attached to a specially-shaped crank S (Fig. 1) on the gland spindle G S to which the pointer I is attached. A weight W on a cranked extension of I, Fig. 4, keeps the roller R pressed up against the flat on the plate;



FIGS. 1, 2 AND 3. HORIZONTAL AND VERTICAL SECTION THROUGH THE INSTRUMENT. FIG. 4. DETAILS OF CRANK MOUNTING. FIGS. 5 AND 6. DETAILS OF ORIFICE AND THE COOLING CHAMBERS

Details of the characteristic crank mounting are illustrated in Fig. 4. This part of the mechanism is visible in the actual instrument through the glass cover of its cylindrical casing; above, the casing opens out into the dial sector. The orifice fitted into the steam main, with its cooling chambers and the carrier, is shown in Figs. 5 and 6.

Copper pipes connect the cooling chambers of the orifice, Fig. 5, with the tubes C_1 and C_2 of the meter (Fig. 1). The difference of pressure across the orifice acts on the two sides of the stout rubber diaphragm D, the peculiar shape of which can be seen in Figs. 1 and 2. The diaphragm is held between two helical tension springs H S_1 and H S_2 and any change of pressure on the two sides will cause the diaphragm to move. In the instrument and diagrams the steam flow is from left to

in this way the movement of the diaphragm is transmitted through S to the gland spindle (Figs. 2 and 3). The way in which the plate P is held between the springs H S can be seen in Fig. 1; the roller is moved to the right or left of its central position, and this movement is repeated by the indicator. The whole mechanism is simple, and the only complication is the shaping of the crank S adopted in order to admit of an adjustment of the roller radius for compensating any variation in the elasticity of the springs H S. The roller R is set to the right radius by springing the crank inwards or outwards by means of the small screws (Fig. 1); R is then locked, and needs no further adjustment even when the diaphragm is changed.

One of the special features of the instrument is that this change of diaphragm can be made without affecting

the calibration of the instrument; the calibration is effected under water pressure. To change the diaphragm D, it is only necessary to remove the nut N_1 (Fig. 1) which holds the spring H S_2 in place, and further to remove the right-hand casting F; the nut N_2 having been undone, the diaphragm can then be taken out. The spring anchor which the nut N_1 fixes is tapped internally so that a wire can be threaded into it as well as through the casting F and the nut N_1, when this latter is being replaced. The instrument is set to zero by unscrewing the cap A (Fig. 1) and by turning the nuts covered by the cap. The instrument can be equalized in order to check the zero by opening the valve V, after closing the two plug cocks P V (Fig. 1). Any air in the meter finds an outlet through the air vent A V, when the equalizing valve is opened; by these means both sides of the diaphragm can be freed from air. The motion of the crank at the end of the gland spindle is taken out to the pointer through a hat-leather gland L (Fig. 3), which will last for years without requiring any attention. The gland spindle itself is carried in a separate casting which is easily removed for inspection at any time.

The main advantages of the new indicator are its easy installation and adjustment. There is no mercury, and the only adjustment that has to be made after the instrument leaves the work concerns the zero. That adjustment, as we mentioned, is effected by the aid of the nuts at A, which in the latest types of the meter are operated from outside through a gland. The diaphragm D is not liable to be damaged in any way. The handles of the plug cocks P V are so arranged that the down-stream cock P V_2 must be thrown open before the up-stream cock P V_1 can be opened, and the diaphragm is supported on the ring shown in Figs. 1 and 2 while the pressure is being turned on. If the diaphragm should fail, however, it can easily be replaced even by unskilled hands in a few minutes, without interfering with the adjustment of the instrument.

The indicator scale is sufficiently large to take readings from a considerable distance. The meters are guaranteed to work with ± 2 per cent absolute accuracy at full load, and within 2½ per cent at half-load. The instrument installed at West Brompton has not yet been checked by tests; more orifices are being added at that station, however, and control tests are soon to take place. The accuracy realized with similar instruments of Messrs. Kent at the Hackney refuse destructor plant reaches 1 per cent, we understand. By means of a fitting, not shown on our diagrams, one of these indicators can be joined to several orifices.

IN THE city of Bath, Me., while workmen were busy recently, quarrying out stone for a stone-crusher, they uncovered, at a depth of about 20 ft. from the surface, a natural water conduit about 3 ft. wide and 2 ft. high. This conduit is in the solid ledge, has been opened up for a distance of 200 ft. and is of a uniform diameter the entire way.

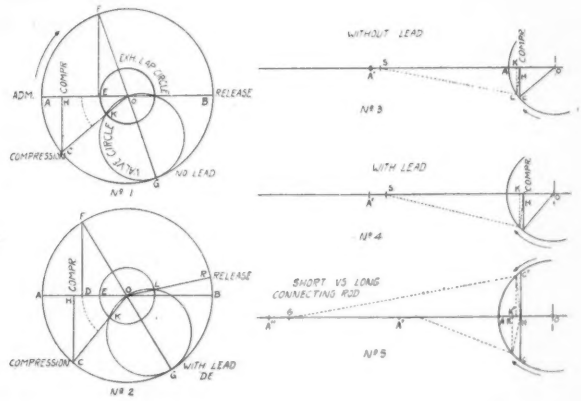
The four sides are corrugated deeply, showing that at some time water ran through it at great pressure. Many people have visited the interesting spot, as very few have ever before seen one of nature's pipe-lines exposed.—Valve World.

Equalizing the Compression

BY ROBERT GRIMSHAW

JUST AS "most of the troubles that we have had never happened," so most of the difficulties with the engine-runner's bugbear—valve setting—do not exist, at least just where they are expected. Probably the bulk of them are in connection with equalizing the compression on both ends of the stroke. As most of these troubles come from the influence of the connecting rod and the engineer's ignorance of that fact, it might be interesting to study it, in an effort to banish the bugbear.

Of course, no matter how squarely the valve is set (we are speaking of an ordinary crank-driven slide-valve engine with no tail rod) there may be, and usually is, more steam passage clearance at one end of the



DIAGRAMS ILLUSTRATING METHOD OF EQUALIZING COMPRESSION

cylinder than at the other. Clearance between the piston and the cylinder head is a matter of safety, and is easily regulated so as to be the same at both ends of the stroke. That regulation is necessary more often with vertical engines than with horizontal; there is also a difference, however, in the clearance, due to the fact that the piston rod has a certain amount of volume—say 1/50 of the piston displacement—and this slightly lessens the non-adjustable clearance at the head end.

These clearances usually can be measured by putting the engine on each center and filling all the spaces (steam passages and counterbore space) with water. Where the chest is on the side, which gives good drainage, this will be difficult; but a soft-wood strip as wide as the vertical lying ports and a trifle shorter will close it all but a slight space at the top for pouring purposes. Every engine runner should know what percentage of clearance his machine has at each end as it will aid him in his first or approximate valve setting.

Having determined the clearance, the next thing is to find out by diagram just where the various events in the double stroke take place in each direction before the valves are set for final adjustment. The indicator will show this quite clearly; but a few drafting instruments will do about the same thing in another way.

Remember that the shorter the connecting rod the greater the inequality of events that it causes. We find it best to let the steam lap alone, and to alter the exhaust

lap a bit; also to neglect the slight influence of the piston-rod volume and the difference in passage clearance.

Let us first assume a valve with no lead.

Referring to the accompanying illustration, No. 1, draw a circle with diameter AB representing the piston stroke on one scale and the valve travel on another; assume that the engine is over-running; and make the diagram clock-wise as shown by the arrow. Draw a circle having a radius EO equal to the exhaust-lap, on the valve-travel scale. Erect a perpendicular EF from the point where this exhaust-lap circle cuts the diameter of the large circle. From F draw the diameter FG. On GO draw the valve circle with diameter equal to half the valve travel. Through the point K, where the valve circle cuts the exhaust-lap circle, draw a radius CO. Then C shows the crankpin position when compression commences; and the perpendicular CH will give us the point H in the piston stroke where the cushion commences. Release will commence just at stroke end, B representing both crankpin and piston positions at this event.

Now assume that there is lead. On AB No. 2 set off DE equal to the amount that the valve has traveled at stroke end. Erect the perpendicular DF; draw the diameter FG; on GO draw the valve circle as before, and through its intersection K with the exhaust-lap circle draw the radius CD; then C will be the crankpin position and H the piston position when cushion commences; and by drawing another radius through L, we get the point R where the crankpin is at the opening of exhaust.

But we have neglected the connecting rod. The diagrams, Nos. 1 and 2, would be correct only for an engine either having an infinitely long connecting rod, or driven by a Scotch yoke as is often the case in tandem steam pumps.

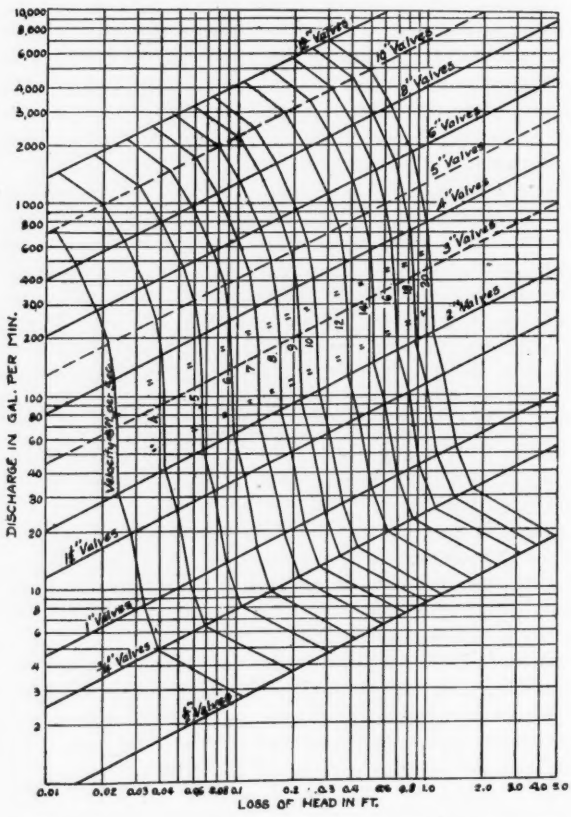
We will assume that the connecting rod is 2½ times as long as the crank throw. In No. 3, prolong the diameter AB and set off AA′ equal to the rod length on the piston-stroke scale (that is, 2½ times AO). Make HS equal to AA′ and with S as center draw an arc from H, cutting the crankpin circle at L. From L erect a perpendicular to AB, which it cuts at K. Then HK will be the amount by which the exhaust lap must be lengthened at the crank end or end of the stroke, and lessened at the back end, to equalize the exhaust compression. This addition is made by screwing on a strip at the crank end of the valve using countersunk screws set below the surface, and planing or grinding the whole smooth. The back end is just planed off smooth.

Sketch No. 5 shows how much greater the influence of the connecting rod is where it is proportionately short than where it is proportionately long.

ONE OF THE greatest pumping engines in the world is the human heart. With each heart beat about 10 cu. in. of blood is expelled from the heart engine. Accordingly in 1 min. or after 75 beats the heart has pumped 750 cu. in. of blood. At this rate it pumps about 225,000 cu. ft. of blood per year. Were the heart to pump water instead of blood, it would expel approximately 7,000 T. of water in the course of 1 yr. And this amount of work is accomplished by a small muscular organ about as big as the average human fist! —Scientific American.

Loss of Head Through Gate Valves

IN A RECENT bulletin of the University of Wisconsin, "Experiments on loss of head in valves and pipes of one-half to 12 in. diameter" by C. I. Corp, professor of hydraulic and sanitary engineering, there is presented a great deal of information, data and charts that should be of interest to anyone having to do with the design of piping systems. In addition to finding the loss through valves, the loss through the pipe itself was determined. The test data indicate that for new



LOSS OF HEAD THROUGH FULLY OPEN GATE VALVES FOR VARIOUS VELOCITIES AND RATES OF DISCHARGE

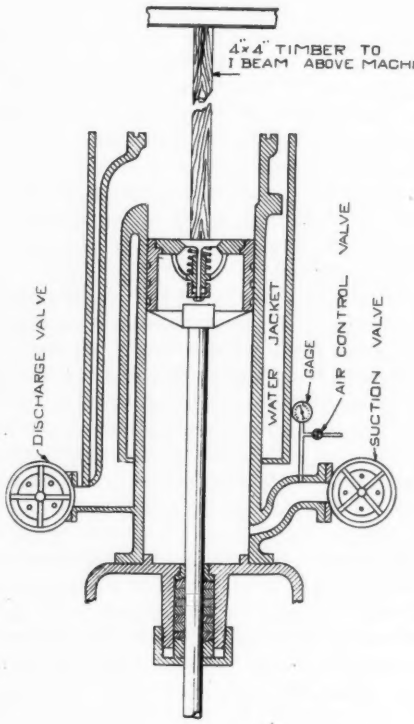
wrought iron pipe the loss of head per 100 ft. of length is as given by the formula $H = 0.0319 \times v^{1.9} \div d^{1.16}$.

From the data obtained on fully open globe valves from ½ to 2-in. size, they produce 16.75 times the loss due to gate valves in the ½-in. size, 23.8 times for ¾-in., 30 times in the 1-in. and 40.7 times in the 2-in. size. The loss through a ½-in. globe valve is approximately equivalent to 35 ft. of ½-in. pipe at the same velocity. That due to the larger sizes tested is probably equivalent to approximately 20 ft. of straight of the valve size.

Loss of head produced by fully open gate valves of any given size is given in the accompanying diagram, for various velocities and rates of discharge. The valves tested ranged from ½ to 12-in. size with discharges up to 10,000 g.p.m., resulting in velocities up to 20 ft. per sec. The loss of head which resulted ranged up to 5 ft.

Inspecting the Ammonia Compressor for Leakage

IN REFRIGERATING or ice making plants where there is only one unit to carry the entire load, the overhauling must be done during the allowable time that the unit can be shut down without interfering with the temperature it is required to maintain.



SECTION OF CYLINDER OF A SINGLE-ACTING VERTICAL COMPRESSOR SHOWING HOW THE SUCTION VALVE AND CYLINDER ARE BLOCKED TO TEST FOR LEAKAGE

To prepare a single-acting vertical compressor for inspection the procedure is as follows: With the compressor free from ammonia and before draining the water jacket, close the suction and discharge stop valves on the compressor, open the purge valve on top of the compressor cylinder head, start the machine and in a few seconds the cylinder should be pumped out.

By placing the palm of the hand over the opening in the purge valve while the machine is in operation, the evacuation of the cylinder will be indicated when no pulsating of pressure is felt. There will be no leak of any consequence in the safety head seat or discharge valve seat. When making this test care should be taken that no air is drawn in through the piston rod stuffing-box or the stuffing-boxes on the valve stems. After this the water jacket should be drained and the compressor head taken off, after which the discharge valves should be taken out. The machine may now be turned over by hand until the piston is about ¼" stroke from the top. At this point the machine should be blocked to resist turning, as shown in the accompanying sketch, when an air pressure is applied underneath the piston. An air connection should be made between suction stop valve and compressor (usually it can be made at the small pump-out connection at this point).

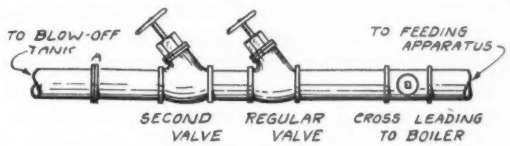
Air is admitted under the piston until a pressure of 20 or 30 lb. is obtained, a gage being placed in the air line to indicate the pressure. About 1/16 in. of compressor oil is poured on top of piston. If leaks are of any consequence, it will be plainly shown by the bubbling of the oil. This will show if any leaks exist in the suction valve, suction valve cage seat or past the piston and rings.

AUGUST GASS.

St. Louis, Mo.

Getting Out of a Blowoff Valve Difficulty

OFTEN WE find it necessary to do some quick acting or thinking to keep some piece of apparatus of the power plant in operation, temporarily or permanently, due to the fact that something has gone wrong unexpectedly.



DUAL ARRANGEMENT OF BLOWOFF VALVES

At one time, I opened a blowoff valve of the Y type to blow some of the dirty water out of a boiler. On closing the valve, it leaked badly and no amount of opening and closing to dislodge the piece of scale between the valve disc and seat was of avail.

As it was nearly starting time, and as it was impossible to shut down the boiler, I decided to let the valve leak for the day, speeding up the pump somewhat to make up for the water that was going to waste through the blowoff valve, until I thought of some way to get out of the difficulty. In thinking the matter over, I remembered that I had an old blowoff valve in stock of the same size and type that was in use on the boiler. On examining this valve, I found that all it needed was a new disc (the valve being of the type where the disc and seat ring can be renewed when worn or cut).

I replaced the old disc with a new one, then decided to stop the leak at the boiler blowoff by connecting the old valve next to the one that was leaking, as shown in the accompanying illustration.

We were able to effect a repair without draining the boiler or stopping production in the plant. There is but little steam pressure in the boiler in the morning before the fire is started, so the next morning I disconnected the blow pipe from the flange "A" up to the leaky valve, then screwed a short nipple into the valve, next screwed the old valve on to this nipple, after which I found a suitable nipple to make connection from this valve to the flange "A."

After these connections were made, I closed the old valve and the leak was stopped; but some time after this, the valve stem at the packing gland of the leaky valve started to leak badly. At first I thought that I would have trouble with the stem, as I was under the impression that the packing in the stuffing-box was hard, not having been renewed for some time, and I would not be able to stop the leak by screwing down on the gland bolts; however, I had no trouble, as after screwing down on the gland nuts the leak stopped.

I believe that the reason the valve stem started to leak after closing the second valve was that the pressure built up between the two valves, which in turn caused full boiler pressure at the leaky valve's stem packing. There is ordinarily no pressure at the packing gland when this type of valve is closed.

At first it was my idea to remove this second valve at the next boiler cleaning when the regular valve could be repaired; but on second thought, I decided to leave the valve in place for further use, should the same trouble again occur with the regular valve. I made no mistake, as the valve was called into service many times on account of the regular valve leaking. When the regular valve is in good condition and does not leak, the second blowoff valve remains open.

Milwaukee, Wis. H. A. JAHNKE.

Peculiar Storage Battery Performance

TO THE average engineer, the actual functioning and performance of the storage battery is none too well understood. The truth of this was recently brought home in the case of a man who purchased a set of Exide iron-clad lead truck batteries, each of which consisted of 12 cells of 17 plates and had a capacity of 272 amp.-hr. and which were secured to replace alkaline type batteries of 21 cells and rated at 225 amp.-hr.

Due to the fact that the charging equipment required extensive changes to fit it for use in connection with the lead batteries, a considerable period of time elapsed from the date of arrival of the batteries to the time they were put in service. In spite of the fact that these batteries had been shipped "charged," they were given a 10-hr. over-charge at 18 amp. The batteries were then placed in the truck for trial, but at once it was evident that they failed to exhibit the "pep" and power that they were expected to possess; in fact, they failed even to perform as did the batteries they were to replace, and these were known to have just about reached the limit of their usefulness.

Voltage tests were then made and it was found that the batteries were producing the required electromotive force necessary to operate the motors. The wiring control equipment, motors and connections, were all carefully examined, but this inspection indicated nothing wrong.

Engineers of the battery manufacturers were then appealed to and at their suggestions the truck carrying the new battery was maintained in service a day, recharged in the regular manner, then placed in service, and again charged. After the third day of use, the battery proved as active as could be expected and has since been in service.

Evidently the trouble was due to the battery having been idle for too long a period, resulting in its becoming sluggish. The repeated charge and discharge renewed it. O. H. H.

Care and Repair of Sparker Points

MISFIRING IN gas engines is often caused by the igniter points not making good contact; for this there are several reasons, the first perhaps being that the spark lever is too short and does not press hard enough on the snatch pawl. To eliminate this trouble, the rod must be lengthened by unscrewing the clip a thread or so, or by drawing it out in the forge and readjusting. The pointed end of the lever must be fairly sharp to give a positive action. When the end has been worn round, there is a chance for misfire because the pawl may jump off before it has had time to make the proper contact. The pawl must be ground on an emery wheel or filed to shape, then rehardened.

Another cause of misfiring is that the sparker points are worn uneven. This uneven wear is caused by the movable electrode stem being worn in the bearing hole. A new stem must be had, the hole bored out and bushed, or the old stem rebuilt by adding metal on the worn places with oxyweld and finished either in the lathe or with a smooth file, and polished. One point may wear much faster than the other on account of different hardness, but often by changing the polarity at the terminals such wear can be stopped.

Materials used in the making of sparking points vary in the many makes from platinum to plain rod iron, but are mostly silver alloy. The nickel points are not satisfactory with some fuels, as the sparker has to be cleaned often on account of the yellow deposit which is nonconductive. Since the war, it has been hard to get the right kind of points at a reasonable price. We tried some high priced point material and had just as much trouble, so we drilled out the worn points and inserted and brazed in place a piece of wire nail. A material that we have found more suitable and cheap is the center rod of old automobile spark plug. Some have to be upset a little, while others are just right if both points are replaced at the same time.

Sparking points must be adjusted, so that they make the best possible contact, either by touching them up with a small smooth file or by shifting the electrodes with the insulating washers so as to get the best contact. It would be expensive to file or indulge in too much sharp emery cloth on real platinum points, but with a small hammer and punch the points may be hammered back in good shape so that no material is taken off. The springs should be stiff and positive, but not tight enough to cause undue wear on the parts affected.

Sparking of a make-and-break system can be improved sometimes by having the points stay in contact a

trifle longer than usual, but this is at the expense of the battery. The battery voltage must be sufficient (6 v.) to give a good red spark, but not over 12 v., as it will wear points faster. In cold weather, a gas engine will start much easier if the voltage can be raised to about 30 v., but this relatively high voltage must not be maintained any longer than is necessary to get the engine warmed up, otherwise the points cannot be expected to last long.

It is well to keep an extra sparker on hand ready for service because when you have to take out the one on the engine, you do not know how much repairing you may have to do and how much time you may lose.

Johnnie, Nevada. CHAS. LABBE.

Regarding the Chief Engineer

I WAS MUCH interested in an article in the issue of Jan. 15, entitled "Regarding the Master Mechanic." There are some points on which I fail to agree with Mr. Shaw. In the first place, no power plant was ever large enough for two executives. Let a firm, after assuring itself of his ability, employ a chief engineer, hold him responsible for the plant and see that he is not interfered with by outside talent, and the best results will be obtained. When the master mechanic, or consulting engineer, is sent to the plant in an advisory capacity, he is likely to feel that the firm has not full confidence in its chief engineer, and he wastes no time in giving the chief to understand that he does feel that way. When repairs or changes are to be made, let the chief send for the master mechanic, tell him what is to be done and how he (the chief) wants it done, then nobody loses any prestige. It is, of course, understood that the chief shall never interfere with the manufacturing end of the plant, or with any work belonging exclusively to the master mechanics' department.

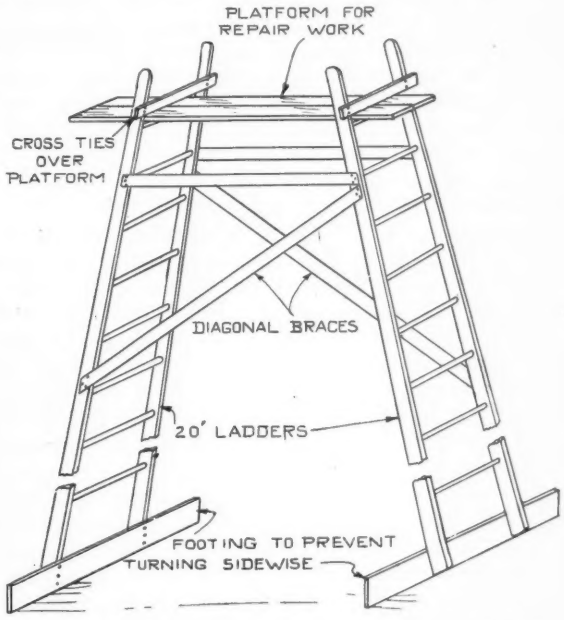
Coming to the point where Mr. Shaw says the chief of a 16,000-hp. plant fell down, it is quite unusual for the chief of a plant of that size to concern himself with the opening and closing of valves, or starting and stopping of engines, but, of course, it is his business to be sure that his assistants are competent to attend to such duties. In well regulated plants it is customary for the assistant going off watch to enter on his log sheet any changes in valves, etc., that have been made for the information of the assistant coming on duty. Such an act as closing an exhaust valve without notifying the man on watch is quite inexcusable.

Camden, Me. M. M. BROWN.

Emergency Scaffold Made of Paint Ladders

WHEN the controls for a skylight in a local machine shop broke recently the height of 25 ft. caused consideration of a built-up scaffold to make the necessary repairs, until the idea shown in the accompanying sketch was adopted. There were available two 20-ft. paint ladders; however, no supporting ledge was available upon which to rest the upper end of either of the ladders. A 10-ft. span of plank was needed to reach the width of the skylight. To obtain this, the two long paint ladders were brought inside the building and annexed by means of diagonal ties, while resting on their sides upon the shop floor. The upper ends were placed 8 ft. apart, while the lower ends were placed about 15 ft. apart. The platform, which was made of two wide planks, was nailed securely to the top rungs, with crossties also nailed to the sides above the planks.

It was a simple matter, upon completion of the bracing, to elevate the improvised scaffold for the necessary



THESE PAINT LADDERS SAVED EXPENDITURE OF $20

repairs to the skylight. This simple device saved a cost of about $20, the estimated amount to provide the materials for the construction of the usual type of rectangular scaffold. G. A. LUERS.

Washington, D. C.

Fire Cracks are Dangerous

DURING THE past 25 yr. I have examined many boilers and the condition of some of them caused me to wonder how they were able to withstand the pressures carried. I have seen boilers with large sections of the plates corroded to such an extent that in some places the metal was only ⅛ in. thick, and yet the gage showed 100 lb. pressure.

Possibly the reason they did not explode was that there were no fire cracks in the sheet. A crack even a fraction of an inch long might have been the one thing necessary to have caused a disastrous explosion.

Fire cracks should be looked for often; they most frequently develop at the girth seam over the fire, especially where there is sediment or scale accumulated over the sheet. A close examination is sometimes necessary to detect the finer cracks. It is quite possible for dangerous cracks to exist and still show no leakage under either a cold or hot water test. Slight cracks are usually located by sight when the boiler is cold; they are seldom located by tapping with a hammer. J. NOBLE.

TESTS MADE at the Pittsburgh, Pa., experiment station of the Bureau of Mines to determine the nature of gases rising from the fuel beds of different kinds of coke show that the composition differs very little.

Some Practical Gasket Hints*

During my 10 yr. of experience with gaskets, the greatest difficulty I have encountered has been to convince users that it is not necessary to tighten a thick flexible metallic gasket with the same extreme pressure as must be applied to thin, non-flexible gaskets. The idea seems to prevail that a gasket, in order to prevent leakage, must have as little thickness as possible and must be squeezed so thin that the distance between the faces of the flanges is a close approach to zero. Often when applying gaskets we see the engineer or pipe fitter slip a pipe over the wrench, thereby increasing the leverage and making it possible to increase still further the pressure against the gasket. As a result, the gasket is squashed. If it is made of corrugated metallic material, it is flattened out so that the corrugations can do no good whatever. It is poor practice to slip a pipe over any wrench on any gasket, because wrenches are generally made of a proper and safe length to fit the nuts for which they are intended. This is a logical safety measure that has been almost universally adopted so that the bolt will not be subjected to an extreme tension. An extra long handled wrench, unless used with extreme care, is liable either to break the bolt or strip the threads.

Our objection to the thin gasket is that no matter how it is constructed it can have but little expanding or contracting capacity, consequently all expansion and contraction must be taken care of in some other manner, such as by means of pipe bends or expansion joints. A thicker gasket, having elastic properties, will naturally take care of considerable expansion and contraction. In many cases, I have known thick flexible gaskets to take care of all of the expansion and contraction in the line—under ordinary temperature conditions of non-superheat practice.

Where temperatures are high, or where temperatures fluctuate considerably, copper, brass and other metallic gaskets having a coefficient of expansion different from that of the joint, should not be used. On account of the difference in the coefficient the gasket and the joint tend to expand and contract independently of each other. The tightly bolted joint, being much stronger than the thin gasket, will compel the gasket to expand and contract along with it. Breakage and leakage are, therefore, often the result. A gasket made up of steel, which has the same coefficient of expansion as the joint, overcomes this latter trouble, but if it is thin and non-flexible, it does not overcome or assist in overcoming the longitudinal expansion troubles.

Hence, when applying thick flexible metallic gaskets, be certain that a wrench of the correct length is used and then tighten only enough so that the leakage is prevented. Do not tighten too much. Any further tightening after leakage is stopped simply reduces the elasticity of the gasket and does not give it an opportunity to "breathe" as it should, simultaneously with the expansion or contraction of the pipe line.

I regard the matter of tightening, therefore, as most important and would like to impress it upon all users of flexible metallic gaskets. By being as careful in tightening the gasket as one is when tightening an ordinary steam engine stuffing-box, or when taking up the wear in a bearing, the best results will be obtained. Take it easy. Don't strain muscles, wrenches, bolts, gaskets, or anything. If directions are always carefully followed, much labor and fatigue will be avoided.

Camden, N. J. Henry Bohmer, Jr.

* All rights reserved by the author.

Inhaled Alcohol Cures Pneumatic System

In our plant we have a pneumatic tube system which is used to carry messages in cylindrical, fiber containers to various departments. The tubes run from the various order departments in the office, out through the yards and to several different buildings. They vary in length from 1000 to 2000 ft. Where they pass through departments in which the temperature of the rooms is 32 deg. or below and out of doors in the yard, the tubes are insulated with hair felt.

Sufficient vacuum to propel the containers is maintained by a motor-operated blower. Air is being continually exhausted. In the winter time or whenever the weather drops below freezing, the warm and moist air from the office, being drawn through some part of the cold tube, causes the moisture to condense on the inside wall of the tube. This collects in large drops and in a short time will freeze, blocking the tube so that the containers will stick and cannot be dislodged until the tube is either thawed out or opened up and cleaned, and it is often difficult to locate exactly where it is blocked. All this causes loss of time in orders being delivered. In order to eliminate this nuisance, several things were tried until at last I hit upon a scheme which has assured us continuous service and stopped once and for all the blocking of the tubes. Once in the morning before any messages are sent through, a pint or more of wood alcohol is put into the tubes. The alcohol is held at the mouth of the tube and as the air passes over it, it is rapidly drawn in. Just before the system is shut down at night, this is repeated.

This eliminates the installing of any expensive air-drying equipment and has given us excellent results.

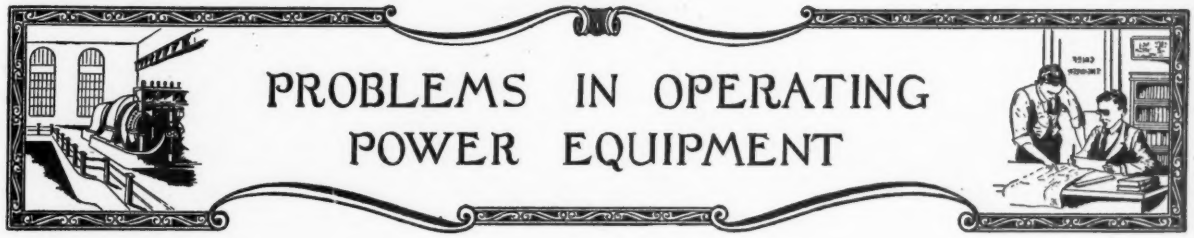
Chicago, Ill. Harold M. Toombs.

Re-babbiting Bearing Boxes

Pipe fitters who have to run a large number of lead joints on heavy cast-iron hub pipes often use a mixture of clay and water on the rope or asbestos binder or dam to prevent the melted metal from escaping. Often the clay is used by itself when re-babbiting bearing boxes, etc. Ordinary painter's putty alone is often used on light work, whether it be a pipe or bearing boxes.

For years I have used for this kind of work a mixture which is much superior to clay or putty; it consists of ordinary putty made thin with cylinder oil and then thickened to the desired density with powdered asbestos. This mixture applied to the hemp rope or asbestos holder will give much better results than clay. It can be used repeatedly and will not harden as clay does after a few heavy runs. It will not soften or blow or run out on small work as ordinary putty has the habit of doing. I have described this plan to experienced pipe layers who have later told me that it had proved of value to them; I am therefore passing it on, thinking that it might be of value to the power plant operator.

John Thorne.



Why This Difference in Popping Pressure?

IN A PLANT where I was once employed, there were three 60-in. by 16-ft. horizontal return tubular boilers. Three 6-in. leads, one from each boiler, connected into a 6-in. header from which a 5-in. line supplied steam to two 50-hp. high-speed engines. The safety valves on these boilers were set to blow at 100 lb. When the engines were running, the valves popped at the correct pressure, but when they were idle the valves opened at 9.5 lb. I have not been able to figure out why this should be so and I would, therefore, like to have the opinions of other engineers on the subject.

J. E. N.

Cutting in Boilers; Pressure Gage Construction

WHEN CUTTING a boiler that is connected in a battery, which stop valve should be opened first, provided, of course, that two valves are used, the one nearest the boiler or the one nearest the header? When a non-return and a stop valve are used, where is the non-return located, nearest the boiler or the main? In this case, which should be opened first in cutting in the boiler?

Why is it that there is one less graduation on the face of a steam gage, from the pin to the first major graduation, than from that to the next major graduation?

These are questions that have caused me some concern and I would appreciate having the opinions of readers on them.

R. W.

What Causes Drop Pipes to Freeze in Cold Weather?

AT THE Seattle Port Commission's ice plant we occasionally have, in cold weather, more or less trouble with the drop pipes freezing at the bottom. Air enters the pipes through a small aperture, not much larger than a pin, at a pressure of about 2¾ lb., and as the drop pipes are about 3 ft. long it means that the air enters against a head of water equivalent to about 1½ lb. per sq. in. The differential pressure then at the discharge opening is about 1¼ lb.

My theory as to why the ice forms always at the bottom and only in cold weather is that the air is expanding through the opening in the end of the pipe, is cooled, and in so doing extracts heat from the water vapor it contains, thus lowering the temperature to a point where the water vapor freezes as minute particles which attach themselves to the lower part of the tube and gradually build up a ring of ice which may eventually close the pipe. This can happen, of course, only when the air entering the pipe is cold enough so that the heat drop due to the expansion will reduce the temperature below the freezing point.

Is this theory correct? If not, what is the explanation? I would appreciate having the opinion of other engineers on this subject.

E. E.

Effect of Voltage on Power Factor

IN OUR three-phase, 240-v. alternating current system, the power factor is unusually low, running about 70 per cent. The mill is equipped with induction motors rated at 200 v. The inductive line drop between the generators and motors is 20 v.; but even with this drop the voltage is still 20 v. in excess of the motor ratings.

Would operating in this manner tend to increase the reactance and influence the power factor, or does it increase the inductance of the line and lower the power factor?

I find that by reducing the voltage at the main board to 220, I increase the power factor to 75 per cent.

The mill claims that 220 v. is required at the motors. This, however, is due, probably, to the fact that the motors are overloaded and will lag at 200 v.

I would like to have the opinions of some of the readers in regard to the best methods of operating.

S. A. D.

Air Lift Pumping Equipment

I SHOULD like to have the opinion of Power Plant Engineering readers in regard to air lift equipment for supplying water in large quantities. At present we have one lift supplying 170,000 gal. per 24 hr. Our arrangement consists of an 8-in. casing set close to the river bank, with a 3-in. well inside of the casing, and a 4-in. intake to the casing 3 ft. below the extreme low water level. The casing is 90 ft. deep with the intake connected 33 ft. from the top of the well.

From the well we have to bring the water horizontally 100 ft. to the levee, then up a 45-deg. slope having a rise of 27 ft. The air is vented on top of the levee and the water spills into a 6-in. pipe and flows by gravity 1000 ft. to a settling basin close to the power house.

At present we pump sewage to the river over the same levee. Would it not be possible to handle this sewage with air lift equipment instead of with a steam pump? How would the cost of the two systems compare?

J. O. S.

Variation of Air Pressure in a Long Vertical Line

RECENTLY IT was stated to the writer that an air compressor would not deliver the same amount of power, at the end of the discharge line, if the line ran up from

the compressor, that it would if it ran down. Is this statement true, and if so, why?

Assume that the discharge line from a compressor, such as is used in a mine to operate pneumatic tools, branches in three directions, one branch running down 2000 ft., one running up 2000 ft. and one running horizontally 2000 ft., the diameter of all the pipes being the same and the friction the same. What will be the static pressure at each point of discharge when there is no flow?

I believe that the same amount of work can be done at the end of either of the three lines and that it is a matter of no consequence whether the line runs up or down, but I would appreciate an opinion on the subject. If I am in error, I would like to know the formula for finding the difference. J. S. F.

A. Inasmuch as air has weight, there will be a variation in absolute pressure at various heights depending on the weight of air to be considered above the point in question. Take, for instance, the question of atmospheric pressure; it is a well known fact that there is a reduction in the barometer as the altitude increases. Whereas, the barometer pressure at sea level may be 30 in. of mercury, at an altitude of 4000 ft. it will be only about 26 in.

One equation developed to show the effect of altitude on the barometer is

$$H_1 - H_2 = (B_2 - B_1) \div (B_2 + B_1) \times 55{,}760$$

where H_1 and H_2 are the high and low altitudes, and B_1 and B_2 the barometric pressures at H_1 and H_2, and the temperature at each point is 60 deg. F.

Making use of this equation, we may find the barometric pressure at 2000 and at 4000 ft. above sea level. Standard barometer at sea level is 29.92 in. mercury, or 14.7 lb. per sq. in., so that we may write

$$2000 = (29.92 - B_1) \div (29.92 + B_1) \times 55{,}760$$

or by transposition

$$2000 \times 29.92 + 2000\,B_1 = 29.92 \times 55{,}760 - 55{,}760\,B_1$$

or $(55{,}760 + 2000)\ B_1 = (55{,}760 - 2000)\ 29.92$, whence $B_1 = 27.9$ in. mercury, or 13.7 lb. per sq. in. Similarly at an altitude of 4000 ft.

$B = 26$ in. mercury, or 12.72 lb. per sq. in.

If we assume that this equation will hold for higher pressure, we may substitute absolute pressure for barometric readings. Suppose we have a mine compressor at an altitude of 2000 ft. with one discharge line running down to sea level and one running up to the surface at an altitude of 4000 ft., and further that the discharge pressure at the compressor is 100 lb. gage. From the foregoing, it will be seen that the absolute pressure at the point is 113.7 lb. per sq. in. Using this figure in our equation, we may find the absolute pressure at the surface.

$$4000 - 2000 = (113.7 - P \div (113.7 + P) \times 55{,}760$$

from which $P = 105.8$ lb. abs.

or since the atmospheric pressure at this point is 12.72 lb., the gage pressure is $105.8 - 12.72 = 93.08$ lb.

Similarly the pressure at lower discharge at sea level will be found from the equation

$$2000 - 0 = (P - 113.7) \div (P + 113.7) \times 55{,}760$$

or $P = 122$ lb. abs. or 107.3 lb. gage

From this it will be seen that there is an increase in pressure and consequently in the work available at the lower discharge which would amount to about 7 per cent in the case cited. It would thus seem that the ideal location of a mine compressor would be at the mouth of the mine.

There is, however, another factor that must be taken into consideration and that is the reduction of volumetric efficiency of the compressor at high altitudes. This will amount to about 6 per cent of a difference of 2000 ft. altitude in the range under consideration, so that actually the saving possible by placing the compressor at the surface amounts to only about 1 per cent which is negligible. Other considerations such as convenience of operation, radiation from long steam lines and piping expense would have much more weight in deciding the location of the compressor.

Paralleling Exciters

WILL YOU kindly advise me as to the correct method of changing exciters on a generator, after the voltage of the two exciter units has been equalized? Would it be advisable to throw the running exciter into the starting unit or to throw the starting exciter out first? What voltage variation may be allowed before the two units are thrown together?

I am operating a generator having a direct connected exciter. This exciter is provided with a two-way switch to change over to the other independent unit. Is it not true that the voltage goes down when the switch is reversed? V. L.

A. Under no condition should the exciter switch on the starting exciter be pulled until the running or incoming exciter is thrown in. If the exciters are shunt wound, the voltage on the incoming machine must be brought up to exactly the same as that of the starting unit. If the machines are compound wound, however, the voltage of the incoming machine must be raised to within one or two volts of the starting unit, and then thrown on the line. Just how much the voltage of the incoming machine must be less than that of the starting or outgoing unit must be determined by trial, although usually one or two volts will be sufficient.

If the outgoing exciter switch is opened before that of the incoming unit is thrown in, the voltage will not drop but will rise momentarily, due to the effect of self induction to a value that may cause a flashover at the switch or puncturing of the insulation on the generator field coils.

Reasons for Change in Design of Stirling Boilers

WHY IS it that in recent Stirling boilers the three upper drums are all on the same level instead of the middle drum being somewhat higher as in the older types? What advantage is claimed for this type of construction? C. F. P.

A. One of the principal changes in the design of the Stirling boiler is the placing of the three upper drums on the same level and the location of the steam nozzle in the rear instead of the center drum. One of the difficulties with the older design was that when the boiler was operated at overloads with highly concentrated water, there was likely to be considerable priming. The effect of a heavy flow from the center drum was to raise the water level in that drum at the expense of the other two, especially the rear. In certain extreme cases the level in the rear drum has been

known to drop down into the tubes for a considerable distance. As the water gage connections were made in the center drum, the level indicated was higher than that which actually prevailed.

In the new design, both the steam and water connections are in the same drum and both the equalizing tubes between drums have considerably more area, so that the tendency toward pressure variations between drums is largely eliminated and even at high ratings the steam delivered is comparatively dry. In this design the water gage connections are made into the front drum and as a result the gage shows more nearly the correct mean level. The location of these connections has some advantages but is not essential as the maximum variation from the mean level is not great.

In addition to these changes the tube spacing in the mud drum has been altered to provide for more superheater space between banks. In the old boiler the last tube in the front bank was immediately adjacent to the first tube in the center bank; now there is a space of two tubes between the front and center banks, an arrangement which gives considerably more superheater space.

Air in Surface Condensers

I WOULD like to know how the proportion of air and vapor in a surface condenser may be found if the total pressure and temperature in the condenser are known. Any information you may be able to give me will be greatly appreciated. H. J. C.

A. According to the principle of partial pressure the total pressure in any mixture of gases is equal to the sum of the pressures of the constituent spaces if each occupied the same space separately. By finding the pressure of both the steam and the air then we may find the relative weights in the mixture.

The exhaust steam is saturated and in this state there is a definite relation between the steam pressure and temperature. The pressure of the steam can thus be determined, and knowing the total pressure from the vacuum gage, the air pressure may be found.

This can probably best be illustrated by an example. Suppose the absolute pressure in the condenser is 3 in. of mercury (corresponding to a 27 in. vacuum with a 30 in. barometer) and that the temperature of the air-vapor mixture is 100 deg. F. From steam tables we find that the vapor or steam pressure corresponding to a temperature of 100 deg., is 1.93 in. of mercury. Subtracting this from 3 in., we see that the pressure exerted by the air is 3 — 1.93 = 1.07 in. mercury.

The density of steam at 1.93 in. mercury is 0.002,85 (steam tables) so that in every cubic foot of condenser space there is 0.002,85 lb. of steam.

According to Boyle's Law, the product of the pressure and volume of any confined quantity of gas, divided by the absolute temperature is equal to the weight times a constant which for air is 53.34. That is, PV = MBT or M = PV ÷ BT, where M is the weight under consideration and B the gas constant. P is expressed as lb. per sq. ft. Substituting our known values in the equation, we find

$$(1.07 \times 13.6 \times 62.5 \times 1) \div (12 \times 53.34 \times 560) = M = 0.002,55 \text{ lb. per cu. ft.}$$

Here $1.07 \times 13.6 \times 62.5 \div 12$ is simply for the purpose of converting the pressure in inches of mercury to lb. per sq. ft.; 560 is the absolute temperature corresponding to 100 deg. F. (460 + 100 = 560) in the condenser.

Thus the total weight of a cu. ft. of the mixture is 0.002,85 + 0.002,55 = 0.005,40 lb. and the percentage of air in the mixture by weight is 0.082,55 ÷ 0.005,40 = 0.472, or 47.2 per cent.

Elimination of Oil from Boiler Feed Water

IN REFERENCE to my letter concerning the elimination of oil from boiler feed water, which appears in the Jan. 15 issue of Power Plant Engineering, on page 145, and about which F. C. E. asks in the March 1 issue, on page 292, I might add the following, which I trust may clear up the matter.

It is true that where the pressure of steam is low there will be water of condensation, and where there is condensation a compounded oil will give best results, as far as lubrication only is concerned. This is because the compounded oil will emulsify in the presence of moisture, and not wash off as would be the case if a straight mineral oil were used.

Less compounded oil is required to obtain a desired result than can be obtained with a straight mineral oil. The big stumbling block is the general idea that a large quantity of oil must be used, whereas experiment and experience have proven that about one-half of the quantity of cylinder oil generally fed to cylinders will accomplish all that could be desired.

If operators would but recognize this fact and believe it, they could, with safety, use a compounded oil for steam cylinders, simply by finding in any given case the minimum quantity required per unit of time, and then religiously controlling the quantity by such an accessory as a mechanical force feed lubricator that can be absolutely depended upon.

As the majority of operators are still skeptical about the use of small amounts of oil and continue to feed large quantities to cylinders and thus flood the exhaust steam with the excess quantity, then the next best thing to suggest is the use of a straight mineral oil which will separate from the condensate, even if fed in excess quantities to the cylinder.

If the correct oil is used, according to an analysis of the conditions obtained in every given plant, and if that correct oil is fed in the correct way, which is by the controlled feed of a mechanical force feed lubricator, then correct lubrication of the internal parts will be secured, and no trouble will ensue from excess oil in the condensate to be used for boiler feed. It is quite possible to attain these results if care is exercised and proper apparatus is installed to do the work.

Brooklyn, N. Y. CHARLES J. MASON.

PRODUCTION of electricity by public-utility power plants during the first month of 1923 was at the unprecedented rate of 151,900,000 kw.-hr. per day—an increase of nearly 24 per cent over January, 1922, and an increase of nearly 2 per cent over the previous record rate established in December. Starting with August, each month has established a new record for the daily production of electricity. Indications are that the output of electricity by public-utility plants in 1923 will be larger than ever before.

POWER PLANT ENGINEERING

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Keep Up the Safety Work

There is a tendency among many plant executives to regard safety work as somethinng which can be handled by sporadically calling the attention of the men to its value in reducing accidents. It is not looked upon as a regular phase of operation such as maintaining high boiler room efficiency, cutting maintenance costs or any of the other problems which must be solved.

It is quite probable that this attitude has been the direct cause of lack of results in safety work. As A. L. Brown points out in the article on the safety record of one of the du Pont plants, in this issue, the safety idea must be sold from the top down. If the heads of the department do not look upon safety as a part of their regular duties, then the men down the line can hardly be expected to consider such work of any real importance.

As shown in this article the du Pont organization has found that safety work has had a definite dollars and cents value; but even more important, it has resulted in less suffering among the employes and their families. At this plant, the record has been maintained by keeping everlastingly at it. Every man in the power department considers it a definite part of his job to take all possible precautions against accidents.

Safety methods should be looked upon as an operating problem and unceasing attention should be given to this phase of power plant work.

Industrial Research

Nothing has contributed more to further the progress of engineering and human achievement during recent years than the great advances in the field of research. All progress is dependent upon the spirit of research. In the laboratories of our great industrial, governmental and educational institutions of today, the spirit of research is the driving force behind all the great achievements which have issued from those institutions.

There are, broadly speaking, two types of research; scientific research, and industrial research. There is, however, no sharp dividing line between scientific or pure research and industrial research, in fact, industrial research is in many cases nothing more than a continuation of a particular line of scientific research. Industrial research consists in applying the results of scientific research to the solution of engineering problems.

The laboratory of industrial research is a product of the past 20 yr. It is interesting to note in this connection that the newest industries were among the first to adopt this type of research while the oldest industries are the most reticent in adopting it. Thus, in the electrical and chemical industries, the value of research was appreciated from the start and met with almost instant adoption. In the tanning and similar industries on the other hand; old industries where the processes involved were in many cases family assets handed down from father to son, the need for industrial research was not so apparent and its acceptance, therefore, not so rapid.

Today, industrial research is a vital necessity in scores of industries; it is paying big dividends, not only to the industries involved but to humanity as a whole by the conservation of valuable natural resources. C. E.

Skinner, of the Westinghouse Electric and Mfg. Co., in a talk before the Western Society of Engineers recently cited an interesting case which serves to indicate the value of research. Mr. Skinner referred to the influence of industrial research in the transformer industry, particularly as applied to "transformer iron."

As early as 1891 the "so-called" aging of transformer iron was noticed. This "aging" made itself manifest in a gradual increase in the iron losses, with time. Investigation of the phenomena revealed the fact that the aging was due to exposure to high temperatures and the solution of the problem was, either to operate transformers at lower temperatures or to develop iron or steel which would not age. The problem was carried into the research laboratory and in 1905 with Hatfield's discovery of Silicon steel, research in this field underwent extremely rapid development. So fruitful were the results of these researches than by 1906 aging of steel had been completely eliminated.

At the present time iron losses in transformers are less than one-fourth of that which had previously been thought possible. Now, the reduction of the iron loss in transformers may not seem of great moment to the welfare of the human race, and indeed, when considered in relation to other more important things its influence may be insignificant. The achievement assumes another aspect, however, when it is considered that the savings in coal effected by the reduction in iron losses in transformers used throughout the United States, amounts to not less than 100,000 T. annually.

Industrial research has effected wonders in the past 20 yr. but we may expect even greater results in the future. It is encouraging to note that today there are over 500 research laboratories in the country. These laboratories will without question produce great results. One other thing is needed, however, if the greatest benefit is to be derived from these institutions, i. e., co-operation. The researches of one group must be made available to the other groups. Only by correct co-operative research can we expect to secure the greatest benefit from each institution as a unit and at the same time to eliminate useless duplication of effort.

Air-Steam Mixtures Indicate Gain in Economy

It has long been a known fact that a quantity of air mixed with steam was of value in preventing rapid condensation of the steam and the history of steam engineering contains many instances where attempts were made to put this principle to practical use in engines. It seems that this reduced condensation is due to the separation of the molecules of the steam by the molecules of air. Evidently there can be no condensation of steam unless its molecules coalesce.

In an attempt to ascertain definitely the effects of air when mixed with steam and to determine the value of air-steam mixtures for use in engines, Leroy A. Wilson and Charles Russ Richards recently conducted an elaborate series of experiments on the subject at the Experiment Station of the University of Illinois. The results of these tests indicate a definite increase in economy due to the addition of certain quantities of air, and the abstract of the paper covering this investigation which appears in the current issue should be of interest to all engineers.

Continuous Operation Demands Care of Supplies

Engineers, in general, are conversant with the work carried on to effect savings in the production of power. As is proper, it is customary to start with the most apparent waste, or possibly that waste, the elimination of which, promises to show the greatest immediate return. Engineers have taken steps to cut down the waste of fuel, lubricating oil, etc.; these have netted large returns, however, no matter how satisfactory those efforts may have been it is not the place to stop.

Why not make a study into and eliminate many of the numerous small wastes which are known to exist? They may not be large but in a year's time they may easily amount to several hundred dollars or more, enough to pay for the maintenance of some piece of equipment, or to buy some valuable instrument which will make still further savings possible.

Let us check up on a few items. Where has that spare stoker crank shaft been stored? Have the machined surfaces been covered with grease, to prevent rusting? Is it stored conveniently, and is it in such condition that it can be installed in an emergency in the least possible time and at a minimum of labor expense? These are logical and important questions.

Then too, it may be that the pipe fitter was not given definite information as to the nature of that last job. He brought over bolts of the wrong length. His helper's time was wasted because he had to make a second trip to the store house. By the way—now there are two sets of bolts charged up to the job. Was the first set returned to the store house and credit obtained, or allowed to lie around and become rusty and eventually land in the scrap?

Several days ago a new shipment of fire brick and tile was received and stacked just outside the boiler house. Those brick should be put under cover because they will not withstand the elements without a considerable loss and that means the fire brick charged to the job as material for maintenance from which no benefit will be derived.

Any amount of good packing has been spoiled due to storage under unfavorable conditions. The subject of packing will illustrate another point. Supplies held in stores represent an investment upon which interest is being paid, it is therefore evident that a reasonably quick turnover of supplies is desirable. It is further desirable that supplies be stocked in proportion to the demand. How often it happens that the packing that is used the most is out of stock, while there is an over stock of a kind that is very seldom used?

These are but a few of the numerous small wastes. The lack of proper maintenance material at just the right time may be the direct cause of a serious shut down. Repair parts allowed to deteriorate in storage mean lost time in preparing them for service. Indefinite instructions lead directly to additional labor expense. Over stocked material represents a waste due to unnecessary investment and repeated last minute rush orders lead to confusion, mistakes and expensive delays.

Give time occasionally to the study of these details. Analyze that last job and see if you cannot find where some saving could have been made. Plan the next job so that it will be a credit to you and a satisfaction to the boss.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

Testing Set for Transformer Oil

IN THE accompanying illustrations are shown views of a new portable oil-testing set which has recently been developed by the General Electric Co. This set is designed to fulfill the need of the smaller stations where the small amount of transformer oil to be cared for does not justify an elaborate equipment. It will also be serviceable to the larger operating companies, not only in the routine testing of oil in transformers at substations and distant points but because of its portability and simplicity of operation the set makes it convenient to check up the quality of oil in drums at the time transformers are being filled. Such practice eliminates any drums which may have collected water in transit and frequently saves the expense of filtering all of the oil which might be contaminated by any of the drums containing moisture.

FIG. 1. NEW PORTABLE OIL TESTING TRANSFORMER, CLOSED

This set includes a transformer of the same general design as the transformer used in the "Coolidge" portable X-ray set, which has in this manner been thoroughly tried out in service. The tank and cover are aluminum castings finished in black enamel. Special precautions have been taken to avoid leakage of the insulating compound with which the transformer is filled instead of oil. The complete apparatus weighs about 50 lb.

Suitable attachment cords are provided so that the set may be supplied from lighting circuits of 110 v., 50 to 140 cycles. Its ends are brought out through two high voltage bushings, which also act as supports for the oil-testing spark gap. High tension voltages of 15, 17.5, 20, 22.5, and 25 kv. are obtainable by means of a ratio adjusting switch provided on the cover of the transformer. The line switch is mounted on the carrying cover, which can be removed to a safe distance. This switch opens and closes the circuit through a suitable resistance, which is housed inside of this cover.

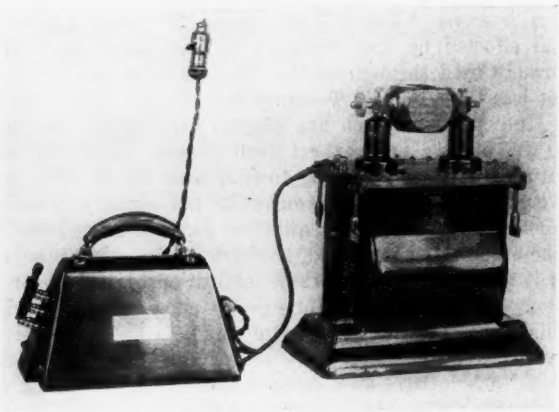


FIG. 2. OIL-TESTING SET WITH COVER REMOVED

This method of switching avoids voltage wave distortion and the consequent incorrect measurements when the transformer is thrown on the line.

Oil is tested in the oil-testing cup, which contains the disk spark gap. This cup has been specially designed so that only one point of oil is necessary to meet the test specifications of the A. S. T. M. both as regards the number of tests to be given each specimen, and the oil level over the electrodes at the time of testing.

New Automatic Starter Is of Compact Construction

AUTOMATIC STARTERS for squirrel cage induction motors have been available for a number of years in various forms and styles, but the older types were large and cumbersome and took up much valuable space in the shop or factory. To fill the need for a more compact unit, a new automatic auto-starter for squirrel cage induction motors has been developed by the Westinghouse Electric & Manufacturing Co. The new

starter, known as the type AF, incorporates a number of improvements in design which make possible a decrease in size with, at the same time, an increase in reliability of operation.

This starter requires no experience or skill to operate since it is not necessary to move a lever or handle in a definite direction or in a certain sequence. All that is necessary is to operate a master switch, various forms of which can be employed. For remote control by an operator, push buttons located at convenient points can be used. Full automatic operation, which eliminates the presence of an operator, is obtained by the use of a float switch or a pressure gage relay, and thus the level of a liquid in an open tank or a certain pressure of a gas or liquid can be kept within predetermined limits.

Since the starter is automatic in operation the motor is accelerated in a time that is consistent with the application and not according to the will of the operator. This gives the shortest time for safe acceleration and prevents auto-transformer burnout and the abuse of the motor and the driven machinery. When the master switch is operated, the start magnet is energized and the motor is connected through an auto-transformer to the line. After a definite time, determined by a time limit accelerating relay, the start magnet is de-energized and the run magnet energized. This operation opens the start contacts which disconnect the motor from the auto-transformer and close the running contacts, connecting the motor directly to the line. When the stop button is pressed or the master switch operates to open the control circuit, the run magnet is de-energized, the run contacts open, and the motor is disconnected from the line and comes to a stop.

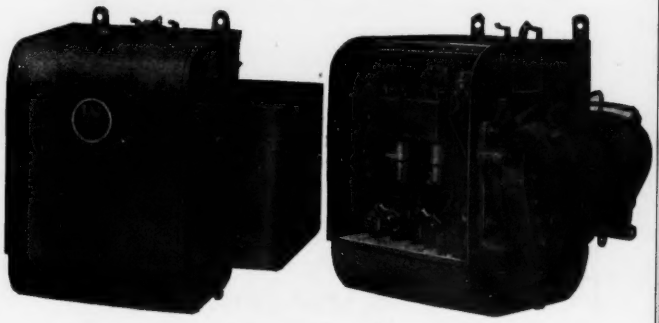


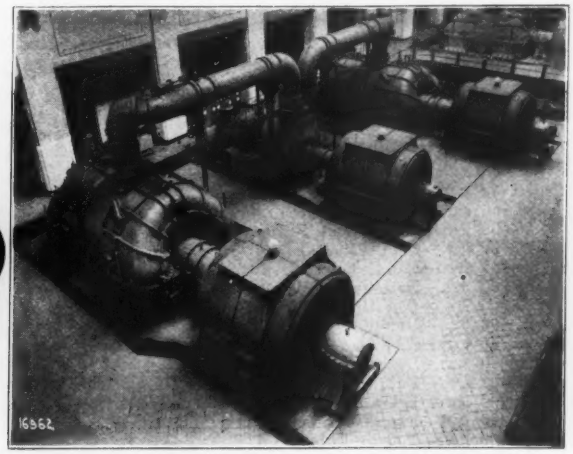
FIG. 1. TYPE AF AUTOMATIC AUTO STARTER
FIG. 2. SIDE VIEW OF STARTER SHOWING CONSTRUCTION OF THE OPERATING MAGNETS

Overload protection on all phases is insured by a two-coil, overload relay connected in two of the phases. An inverse-time-limit arrangement prevents the overload relay from opening the circuit on instantaneous peak loads, but gives complete protection to the motor on any prolonged overload. The overload relay is fitted with a latch which prevents starting the motor after an overload until the relay has been reset electromagnetically by a reset push button.

Both starting contacts and running contacts are of the same size and are actuated by a dual magnetic mechanism which automatically closes the starting contacts first, holds them closed for a predetermined time, depending on the setting of the accelerating relay, and then automatically opens the starting contacts and at once closes the running contacts. The moving armature, which is common to both magnets, moves between the magnet frames and its motion rotates the shaft which carries the main contacts. Interlock fingers are connected to the rotating shaft so that when the starter is in the running position these interlock fingers make a circuit which maintains itself through the run magnet. The run magnet, therefore, also functions as a low voltage relay. The control relay is given a definite time limit by means of a dash pot so that the time of starting a motor can be adjusted for any period up to a maximum of 15 sec.

Many Large Turbines to Be Installed This Year

INCREASING demands for service being made on central stations, necessitating rapid expansion of generating capacity, is reflected in the number of orders for large turbines which have been announced. In a number of cases public utilities have been unable to await the completion of projected new plants, but have been forced to purchase primary power generating apparatus at once.



THIS IS A 60,000-KV.A. CROSS-COMPOUND TURBINE IN CHESWICK STATION OF DUQUESNE LIGHT CO.—UNITS OF 62,500-KV.A. OF SINGLE CYLINDER ARE NOW BEING BUILT FOR BROOKLYN EDISON CO.

Among the machines which are now being built by the General Electric Co. are three 50,000 kw. turbines for installation in a new station at Trenton Channel for the Detroit Edison Co. The American Gas & Electric Co., New York, has placed an order for four 35,000-kw. Curtis turbines for a new station at Philo, Ohio, to supplement its Windsor (West. Va.), station in serving the Ohio territory. A considerable amount of switch gear and transformer equipment is included. These turbines will operate at 530 lb. steam pressure and are designed for constant operation at full load.

Orders for 30,000-kw. turbines have been placed by the Cleveland Electric Illuminating Co., the Public Service Co. of Northern Illinois, Joliet, the Minneapolis General Electric Co. and the Commonwealth Edison

Co. of Chicago. The Philadelphia Electric Co. has ordered two units of this size. In the case of the Cleveland, Philadelphia and Chicago orders, although new stations are planned, the demand has been so great that these units will be added to existing stations as soon as shipment can be made.

In the east, the New York Edison Co. has ordered a 35,000-kw. turbine and a 35,000-kw. frequency changer. One of the problems of d.c. distribution fed through 25 and 60-cycle rotary converters is to prevent the attempted transfer of disturbance on either system to the other through these rotaries, thereby causing them to fall out of step and shut down. The new frequency changer set to be supplied the New York Edison Co. is especially designed to relieve this strain on the rotary converters. It provides an electrical tie which will operate quicker than the converters and allow the momentary transfer of about 100,000 kw.

It has been announced by the Westinghouse Electric & Manufacturing Co. that in the last few months orders have been received for steam turbine-generators aggregating nearly 600,000 kw. These machines have been purchased by leading central stations and large industrial plants located all over the country.

Included in these orders is the largest machine ever built by the company—62,500-kv.a. generator for Brooklyn Edison and the machine with the highest steam pressure 500 lb., 50,000 kw. for the Commonwealth Edison Co. Among the machines which are now going through are the following:

62,500 kv.a.—Brooklyn Edison Co.—Hudson St.
50,000 kw.—Commonwealth Edison Co.—Crawford St.
37,000 kw.—Commonwealth Edison Co.—Calumet
2—30,000 kw.—West Penn Power Co.—Springdale.
3—25,000 kw.—Connecticut Light & Power Co.
2—25,000 kw—Middle West Utilities Co.
2—25,000 kw.—Indiana Public Service Co.
25,000 kw.—Counties Gas & Electric Co., Norristown, Pa
25,000 kw.—Denver Gas & Electric Co
25,000 kw.—Moline & Rock Island Mfg. Co.
25,000 kw.—Luzerne County Gas & Electric Co.
25,000 kw—Public Service Production Co.—Jersey City.
25,000 kw.—Lorraine (O.) County Gas & Electric Co.
25,000 kw.—Penna. Railroad, Long Island City.
37,500 kw.—Toledo Edison Co.
37,500 kw.—Metropolitan Edison Co., Reading, Pa.

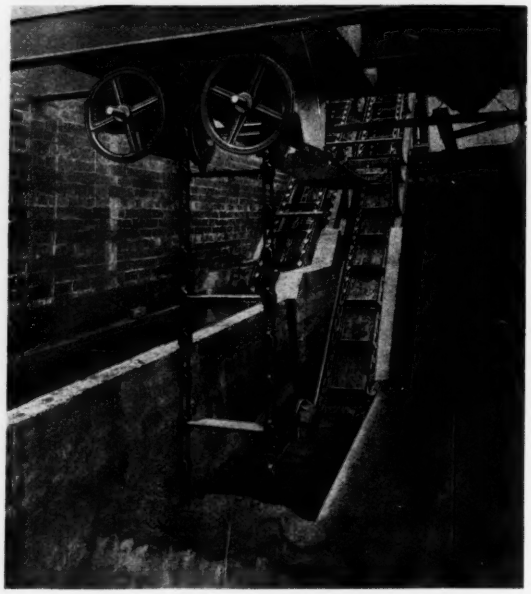
Commenting on this large amount of business, E. H. Sniffin, Manager, Power Sales Department of the Westinghouse Co., stated: "The amount of steam turbine business that will be done this year will only be limited by the manufacturing capacity."

Water Sealed Ash Conveyor

AFTER a number of successful installations had been made in Europe, a new type of ash conveyor has made its appearance on the American market. This apparatus, the Combusco Water Seal Ash Conveyor, built here by the Combustion Engineering Corp. of New York, consists essentially of a double chain scraper or drag conveyor moving in a trough containing water, the trough being located under the ash discharge from the stoker. Ash and clinker fall from the stoker or through the clinker grinder directly into this trough and are quenched and are immediately carried along by the conveyor and deposited in a large hopper or car.

In the usual form the ash chute or stoker hopper terminates in a spout which dips below the surface of the water in the trough, thus providing a water seal against the entrance of air to furnace at this point and also excluding dust from the basement.

This conveyor is designed to operate continuously, taking the ash from the grate as it is deposited, thus eliminating the necessity of large stoker hoppers re-



VIEW AT END OF COMBUSCO SINGLE TROUGH CONVEYOR. THE INCLINED ELEVATOR AT THE RIGHT IS USED FOR CONVEYING ASH FROM AN INDUSTRIAL CAR, USED AS AUXILIARY, TO THE BUNKER

quiring excessive headroom in the basement. This system can be installed in a 4-ft. trench, running under the boilers in front of the bridgewall.

Portable Electric Blower Facilitates Cleaning

FOR removing grit and dust from motors, generators, switchboards and other power plant equipment a portable electric blower has recently been developed by the Clements Manufacturing Co., of Chicago. This blower has a weight of 6 lb., has a ½ in. nozzle outlet and flows about 20 cu. ft. of free air per minute with a motor speed of 11,500 r.p.m.

Since there are many places where compressed air is not available this blower has a wide range of useful-

BLOWER WHICH HAS BEEN DESIGNED FOR CLEANING OUT INACCESSIBLE PLACES

ness. As the blower may be connected to an ordinary lamp socket, it may be used when the plant itself is not in operation.

Sale of War Supplies Saves Over Billion Dollars

SINCE the establishment of a sales branch of the War Department in 1918, a billion dollars has been reclaimed for the treasury and several hundred millions saved the various departments of the Government through sale, proper distribution and use of available surplus war materials, stated Major James L. Frink, chief of sales promotion for the Government in an address before the Chicago Association of Commerce on March 29. The vast liquidation involved in selling these supplies and at the same time not affecting general business adversely has been a problem with many difficulties as shown by Major Frink in this address.

In May, 1918, Congress first authorized the President in his discretion, to sell such surplus materials as might accumulate. Two months later the President's powers in the disposal of surplus property were considerably broadened. These dates, as pointed out by Major Frink, are of first importance, because of their indication of the fact that even in the midst of war, the department charged with the defense of the nation was preparing for peace; they also indicate the sound judgment displayed by the War Department in anticipating conditions, which resulted in the so-called "buyers' strike" in 1920.

Early sales made between the date of passage of the first emergency legislation regarding surplus property and January, 1919, were supervised by a Committee of the War Department General Staff, under General Goethals, and amounted to some $123,000,000.00. Soon after the signing of the Armistice, the amount of business became so great that it was impracticable to handle it longer through a Committee, and accordingly, in December, 1918, a Sales Branch was established under an official designated as the Director of Sales, whose duties may be defined briefly, as follows: To formulate, supervise and co-ordinate the selling of surplus supplies, materials, equipment, by-products thereof, buildings, plants, factories or lands embraced within the Act of Congress approved July 9, 1918.

At the time of the establishment of the Office of the Director of Sales, estimates of the probable total amount of surplus that would eventually result from demobilization and the decreased requirements of the permanent peace-time military establishment varied between two and three billion dollars.

These supplies consisted of an almost untold variety of articles; the Quartermaster Corps alone listed more than 65,000 separate items exclusive of transportation and real estate.

During the first year of liquidation, sales were made by negotiation, sealed bid, fixed price and auction. According to Major Frink, each succeeding year has increased the difficulties of selling, and caused a revision of methods. At the present time no sales are made by negotiation unless the property concerned has first been offered to the public at large by sealed bid or auction and failed to bring a satisfactory offer.

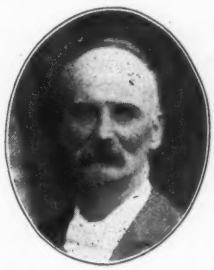
Progress of liquidation has in the main been extremely satisfactory and gratifying to those connected with the business organization of the government. Sales have kept abreast the declarations of new surplus reported from the various Supply Departments and from now on should exceed these declarations by a good wide margin. Since the establishment of the Office of the Director of Sales property originally valued at over two billion dollars has been sold and the visible supply reduced to about $200,000,000. Estimates of future surplus to be reported will swell this total to approximately $400,000,000 cost value, which still remains to be sold.

In outlining the method to follow in buying from the War Department, Major Frink stated:

"Permit us to place your name on our mailing lists to receive catalogs and other announcements of sales of materials in which you may be interested. When you get this literature, look it over, select the items you want —if sold by auction, send your representative to the sale with sufficient funds to satisfy the preliminary conditions announced in the catalog—if a sealed bid sale, send in your bid, accompanied by a certified check for the required percentage for deposit. Remember, if you will, our auctions are not wild scrambles or cheap affairs at all, but businesslike functions in keeping with the dignity of the government and its prospective customers."

Death Ends Ninety-Years Career of James J. Beckerleg

ON MARCH 7, the death of James J. Beckerleg, in Chicago, marked the close of the career of a man actively interested in stationary engineering practice in this country since 1849. Mr. Beckerleg was one of the founders of the National Association of Stationary Engineers in 1881, and in 1883 and 1884 held the office of president. He had the distinction of being the only man who was honored with this office for two terms.



Although at the time of his death Mr. Beckerleg was nearly 90 yr. old, he maintained an active interest in the association until the last. In fact, during the 41 yr. of the association's history, he missed attending only one of the national conventions.

Mr. Beckerleg was born in St. Ives, Cornwall, May 7, 1833, and after a period of seafaring life, came to the United States in 1849. His first work was in a boiler shop in New York City and later he was employed by the Baltimore & Ohio R. R., first as a machinist and then as a locomotive engineer. After filling the duties of locomotive engineer for 2 yr. on this road he resigned and was employed in the installation of steam apparatus at the Treasury Department, Washington, D. C., for 3 yr. He was then transferred to the Post Office Building at Chicago, arriving May 16, 1860. Later he was sent to the Government Building at Indianapolis and then returned to Chicago as chief engineer of the Government Building for a period of 6 yr. After a year with Crane Bros., he spent 30 yr. with Leopold Brod & Co. In 1903 he went with the Dearborn Chemical Co. as salesman in the downtown territory and in 1914 he was retired on a pension.

Ford Gets Power Rights on Mississippi at St. Paul

ON MARCH 2 the Federal Power Commission granted the Ford interests a preliminary permit for the High Dam project at Minneapolis and St. Paul. This action of the Commission resulted from a vote of the Minnesota legislature which showed an indorsement of the Ford industrial development program by throwing out the Leach municipal ownership bill.

By the terms of the permit, Mr. Ford is required to apply for a license before July 1. He will also be required to install the maximum capacity and must sell the surplus power. It is probable that the Northern States Power Co. will be able to utilize the surplus if satisfactory terms can be arranged. An annual charge of $95,000 will be made by the Federal Government for the use of the dam.

This award settles a question that has been troubling the twin cities ever since the dam was raised from its original height of 30 ft. and became known as the High Dam. By the decision, the full program of industrial development contemplated by Henry Ford, when he first became interested in the possibilities of the Mississippi River at St. Paul, will be carried out. It is expected that between 14,000 and 15,000 men will eventually be employed at this new manufacturing plant. At first there will be about 3000 men on car production and 1000 or more on parts production.

News Notes

WARREN STEAM PUMP CO. has opened an office in the Marbridge building, New York City.

COLONEL H. D. SAVAGE, head of the pulverized fuel department, Combustion Engineering Corporation, addressed the Engineering Institute of Canada on March 15 on the subject of pulverized fuel, and its application.

EVERETT M. STEVENS, for 14 yr. with the Bundy Steam Trap Co., Nashua, N. H., and the past 7 yr. as New England representative, has been appointed sales manager, with headquarters at the home office in Nashua.

UEHLING INSTRUMENT CO., Paterson, N. J., manufacturer of CO_2 recording instruments, has appointed the Combustion Engineering Corporation, Ltd., with head office in Toronto, and branches in Montreal, Winnipeg and Vancouver, as its Canadian engineers and sales agents.

W. A. CATHER, recently a member of the sales promotion and advertising staff of the Worthington Pump & Machinery Corporation, New York, has been advanced to the position of general sales assistant in charge of sales promotional work.

APPLICATION has been made by the Interborough Rapid Transit Co., of New York City, to the Transit Commission for permission to renew its contracts with the Berwind-White Mining Co., the Consolidation Coal Co. and the Logan Co. to supply coal for a further period of 3 yr. The amount of coal involved is 800,000 T., at a base price of $7.50 per gross ton at the power houses, with provision of a sliding scale covering increase or decrease of freight rates or miners' wages.

IT IS reported that the Santa Fe Railroad is contemplating the electrification of its road between Kansas City Albuquerque, N. M. Fuel for the power plant will be natural gas from the gigantic wells discovered in the Panhandle fields of Texas.

CHARTER GAS ENGINE CO., of Sterling, Ill., announces the purchase of the entire "Mietz" Oil Engine business, heretofore carried on in New York City by the August Mietz Corporation and the Reliance Oil Engine Corporation. This effects a merger and consolidation, under one management, of two of the oldest internal combustion engines in the world.

AN ORDER has been issued by the Colorado public utilities commission compelling all electric utility companies in the state to use an improved, uniform system of accounts. The system was worked out by the National Association of Railway and Utilities commissioners is in use in 17 states and is said to simplify checking, classification, thus making the records clear to the commissioners.

HARRISONBURG, VA., is to open its new power plant in May. The brick and concrete building to house the auxiliary steam-electric power plant has been completed, and the machinery will arrive in the next few weeks. By May 1, at the latest, it is expected the plant will begin operations, generating 500 horsepower, equal to that of the present output of the hydroelectric station on the Shenandoah River there.

IN 1640, THE FIRST power public utility in the United States was erected at Dedham, Mass. This was a grist mill on a water power canal, formed by cutting Mother Brook, between the Charles River and the Neponset River. And today one of the largest manufacturing concerns, the Bird interests there, is known as the Neponset Mills. The millers share of the grain and grist paid in part for the cost of construction.

ANTICIPATING the end of the coal famine with the approach of warm weather, the authorities of the Department of Health of New York City have announced that the section of the Sanitary Code dealing with emission of dense smoke from buildings, which has been allowed to lapse during the period of stringency, will again be rigidly enforced. It is stated that the supply of anthracite coal for the city during the past season was 40 per cent off from the normal figure.

REPRESENTATIVE HANAHAN has introduced a bill in the South Carolina legislature to extend the charter of the Central Carolina Power Co., giving it five years more to develop the power it has failed to develop in the past 17 yr. The site was recently surveyed by Lockwood, Greene & Co., power engineers and well-known mill consultants. These consultants are the principal owners of the Pacific Mills of Columbia, S. C., the Winnsboro mills, and other large developments. The power site is at Littleton, S. C., 15 mi. west of Columbia on the Broad River.

CONNECTICUT LIGHT & POWER CO. has issued $4,500,000 of 7 per cent first preferred stock and $2,500,000 of 8 per cent convertible perferred stock, both cumulative, the proceeds to carry on the construction program of the company, recently announced in these columns.

The most important of these improvements is the new steam electric generating station at Devon, at the mouth of the Housatonic River, with an initial installation of a capacity of 100,000 hp., which more than doubles the company's present plant capacity. The company at present operates two hydroelectric properties with an aggregate capacity of 34,600 hp.

OKLAHOMA GENERAL POWER CO. at Muskogee, Okla., has included double dump forced draft grates in the three Westinghouse stokers recently purchased. This type of dump grate makes them active fuel burning surfaces, thus increasing the capacity of the installation. Steam power refuse dumps, extension sidewall tuyeres, tall hoppers with extra high ends are included. Oklahoma or Arkansas coal will be available for the new 1020 hp. Edge Moor boilers.

CHATTANOOGA boiler manufacturers are on full production, for the first time since 1920. The three largest plants—Casey-Hedges Co., Chattanooga Boiler & Tank Co. and Walsh & Weidener Boiler Co.—are operating at capacity. Most of the time since 1920, boilermakers have had to slash prices, and were glad to get cost of materials, of labor and part of the overhead.

THE WATER POWER DEFENSE BODY has entered the Ford-Muscle Shoals controversy with a round-robin letter to every member of Congress, received Feb. 6. The siguatures included former Secretaries of War Baker, Garrison and Stimson, former Secretaries of the Interior Garfield and Stimson, former Secretaries of Agriculture Houston and Meredith, and Governors Pinchot of Pennsylvania and Parker of Louisiana. They take the stand that the Ford project is "an assault on the Federal Water Power Act."

AMONG BIG industrial plants entering on programs of expansion in Baltimore is the United States Industrial Chemical Co., whose $1;000,000 improvement program includes an enlargement of its reclamation plant and the construction of a new fertilizer factory. The United Railways & Electric Co., part of the Consolidated Gas & Electric Co., is to spend $2,120,000 on new lines, rolling stock, sub-stations and power equipment, generally. The Consolidated Gas, Electric Light & Power Company is to spend $1,000,000 for new equipment, buildings, power plants, sub-stations, etc.

U. S. CIVIL SERVICE COMMISSION announces an examination for April 25, to fill vacancies in the Customs Service throughout the United States at entrance salary of $1800 a year, plus the increase of $20 a month granted by Congress. The duties consist of the examination and care, including repairing, of the Government's automatic electric scales and electrical appliances installed in connection therewith on the various steamship docks of a port, to insure uninterrupted operation of the scales when required, and related duties. The examination will consist of practical questions on electricity, machinery and scales; report writing; arithmetic, including fractions, weights and measures; and training and experience. Full information and application blanks may be obtained from the United States Civil Service Commission, Washington, D. C., or secretary of the board of U. S. civil service examiners at the post office or customhouse in any city.

Book Reviews

FUEL OIL IN INDUSTRY, by Stephen O. Andros; 6 by 9 in., 198 pages, 95 illustrations, cloth; Fort Wayne, 1922.

An increasing demand for exact information about fuel oil has received an added impetus from recent happenings in the coal industry. Not only is the industrial user of fuel concerned about the irregularity and uncertainty of our coal supply, but the householder as well is now seeking relief from a burden which he has borne patiently for many years.

To supply such information, a revised edition of "Fuel Oil in Industry" has been issued. In the revised edition all subject matter has been eliminated which does not have a direct bearing on the economical storing of fuel oil and burning it under boilers. An entirely new discussion of the heating of private residences is a chapter that will prove interesting to all those who are trying to escape the high cost of supplying coal for private homes and for apartment houses and hotels.

Municipal regulations for the storage of fuel oil are somewhat harsh and a new chapter on storage tanks, their essential qualifications and methods of manufacture will enable both the industrial and domestic user of fuel oil to determine what type of storage tank is best suited to his needs.

SAMPLING AND ANALYSIS OF COAL, COKE AND BY-PRODUCTS, compiled by Chemists Committee, United States Steel Corporation; 5 by 7¾ in., 184 pages, 18 illustrations, leather; Pittsburgh, 1923.

While this book appears as a second edition of the former pamphlet, it really is equivalent to an entirely new work. Not only was all the old material of the first pamphlet carefully re-edited and revised so as to bring all these methods up-to-date, but a great many methods and tests not covered by the former work are included in the new. The amount of this new material is indicated by the fact that the present book is more than double the size of the old.

As presented, the work naturally divides itself into two parts, namely, one covering the sampling and analysis of by-products. The first part embraces the sampling of coal and coke, physical tests on coal and coke, the proximate analysis of coal and coke, the analysis of coal and coke ash, the ultimate analysis of coal, determination of the calorific value of coal and coke, and the determination of coke and by-product yields from coal. The second part covers in detail the sampling and analysis of ammonia liquors and still waste; sulphuric acid, lime and saturator liquor; ammonium sulphate and ammonium chloride; coal tar and naphthalene; benzol, toluol, xylol and solvent naphtha; benzolated and debenzolated wash oils, and coke oven gas.

New features, that is, those not touched upon in the older work, embrace details for sampling by-product coke; physical testing of coke; determination of the different forms of sulphur in coal; fusibility of coal and coke ash; analysis of ammonium chloride, a method for calibrating thermometers; complete specifications for thermometers used for testing liquid by-products; many additional tests for benzol products and tar, such as cloud test, pour or cold tests, freezing point tests, specific heat, corrosion tests, etc.; wash tests for agitator prod-

ucts; and several tables covering gravities, weights and equivalents of sulphuric acid and aqua ammonia, and the conversion factors used in by-product laboratories.

Among the many improvements made in the methods described in the former pamphlet, the most notable are a freezing method for the determination of light oil in the progressive distillation of coal, details for conducting distillation tests on each of the benzol products, and an improved apparatus for the determination of light oil in benzolated wash oil.

THE AGRICULTURAL EXPERIMENT STATION of the University of Arizona has recently issued a bulletin, No. 95, championing the development of the Colorado River and its tributaries. As set forth in this bulletin, the purpose of this development is threefold: First, to provide ample storage for flood protection; second, to provide storage to supply water for irrigation during the dry season; and third, to provide hydroelectric power. The problem is by no means a simple one. In the first place, seven states are concerned with any action that is taken and perfect agreement must be obtained or the development must be done under federal control. In the second place, the engineering aspects are so enormous, so unprecedented that great caution must be exercised.

In all, the watershed covers an area of about 251,000 sq. mi. The average annual discharge of the system into the Gulf of California amounts to about 13,000,000 acre feet. During flood periods, the flow approximates 150,000 cu. ft. per sec. and during the dry season drops to below 4000 cu. ft.

Many dam sites have been considered and each has certain advantages. The Diamond Creek project, for instance, would develop about 110,000 hp. with unregulated flow. With a storage reservoir farther up the river, however, this capacity could well be increased to 600,000 hp. The Boulder Canyon would be able to furnish a like amount or possibly more. A total of 4,000,000 hp. can be developed on this system on the various sites included in the development.

PLUMBERS' HANDBOOK, by Samuel E. Dibble; 4½ by 7 in., 629 pages, 316 illustrations, flexible; New York, 1922.

Reference handbook for the plumbing and heating dealer, the architect, the engineer, the estimator, the building contractor and sheet metal worker. It presents information designed to perfect installations. It covers various phases of plumbing, shows modern fixtures and equipment, presents those facts about heat, pumps, metallurgy and chemistry which the plumber needs to know, and in the section on business methods points out how the modern plumber systematizes and manages his business.

Catalog Notes

ERDMAN FORCED DRAFT BURNER CO., New York, N. Y., has issued a folder covering its combustion system through the use of the Erdman type grate.

AIR TIGHT furnace doors are described in a folder published by the Conveyors Corporation of America. The door proper is hung at the center from a separate frame which is hinged at one side and provided with a clamping device at the other. The door is machined to make an air tight joint with the door frame. The one point suspension insures uniform pressure at all points between the door and frame. Copies will be sent to those interested.

"BOILER MAKERS TOOLS" is the title of an interesting catalog published by J. Faessler Manufacturing Co., Moberly, Mo. It includes various types of flue expanders, tube cutters and counter sinking tools and is very complete in the information given on each.

THE DIAMOND RUBBER CO., of Akron, Ohio, has just issued a catalog describing mechanical rubber goods made by the company. Engineering data is given on transmission and conveyor belts, hose for various purposes, tubing, gaskets, packing, pump diaphragms, valve discs, and numerous other articles of like nature.

STREET LIGHTING AND PUBLIC SAFETY, by Earl A. Anderson (Bulletin 46), has just been issued by the engineering department of the National Lamp Works of the General Electric Co. It is a reprint from the proceedings of the American Society of Municipal Improvements, and deals with the subject of street lighting and its effect on crime and accidents in populated communities.

BULLETIN 1222, just issued by the Esterline-Angus Co., of Indianapolis, Ind., contains some interesting information regarding the recording of condenser leakage and also the measurement of concentration of salts in boilers. The bulletin describes two instruments; one the Condenser Leakage Meter, and the other, a Portable Concentration Meter, both of which are manufactured by the Esterline-Angus Co.

STEAM AND HOT WATER HEATING, catalog No. H-9 of the Oil City Boiler Works of Oil City, Pa., contains some worth-while engineering information of interest to architects and heating and ventilating engineers. Specifications for various sizes of their portable and smokeless return tubular fire box boilers. The pamphlet also contains data on radiation capacities and heat transfer in buildings. Copies will be sent to architects and heating engineers upon request.

KIELEY & MUELLER, of New York City, are distributing a folder describing the Kieley high pressure automatic boiler water feeder. This feeder consists of a centerport balanced water valve actuated by an enclosed non-collapsible iron float in the casing, which responds to the slightest variation of water in the boiler. Another bulletin which has been issued by this organization gives an idea of some of the steam specialties such as reducing valves, back pressure valves, steam traps and other items.

JONES AUTOMATIC—CLEANING UNDER FEED STOKERS make up the subject of publication No. 61 issued by the Sanford Riley Stoker Co., of Worcester, Mass. Underfeed principles of combustion are discussed and the operation of the Jones stoker discribed. There is also a section devoted to a description of the Cole automatic valve which is applied to the Jones stoker and which automatically controls the amount of air supplied in accordance with the amount of coal to be burned. Numerous photographs of well known installations are also presented.